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ABSTRACT

The purposes of this study were to determine the level of achievement of United States advanced science students in an international context and to identify school factors affecting the science achievement of the students. The Second International Science Study (SISS) Advanced Science Achievement Tests included international common items which made possible comparisons of U.S. advanced science student achievement with the achievement of students in other participating countries. Students, teachers, and school administrators responded to structured questionnaires designed to elicit information about student family and science background; student science attitudes and interest in science; teacher background and teaching methods; and school characteristics. The sample included more than 1700 students, 117 teachers, and 115 school administrators. Major results of the study are: (1) each subgroup, biology, chemistry, or physios, had a mean science score below the international mean for the respective test; and (2) across subgroups, the best predictors for student achievement was determined by scores on the SISS Mathematics and Word Knowedge Tests. Advanced science students who had studied at least 3 years of science and mathematics had mean science scores that were not significantly different from the international mean scores. Appendices include course offerings, tests and questionnaires, opportunity-to-learn ratings, frequency of distribution of questionnaires, and correlation coefficients for variables. (YP)

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AN ANALYSIS OF UNITED STATES ADVANCED SCIENCE STUDENT ACHIEVEMENT

by

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Approved by the Committee on the Degree of Doctor of Education

Date______________________________

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requirements for the Degree of Doctor of Education in
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ABSTRACT

AN ANALYSIS OF UNITED STATES ADVANCED SCIENCE STUDENT ACHIEVEMENT

Arleene Marion Ferko

The Study of United States Advanced Science Student Achievement within the context of the Second International Science Study (SISS-U.S.) involved a three-stage probability sampling design. The sample included more than 1700 students, 117 teachers, and 115 school administrators in over 700 public and private schools which offered at least one Advanced Science course (a second-year course) in Biology, Chemistry, or Physics. Science achievement tests in the appropriate subjects, a Mathematics Test, and a Word Knowledge Test were administered to students in the sample. The SISS Advanced Science Achievement Tests included international common items which made possible comparisons of U.S. Advanced Science student achievement with the achievement of students in other participating countries. Students, teachers, and school administrators responded to structured questionnaires designed to elicit information about student family and science background, student science attitudes and interest in science, teacher background and teaching methods, and school characteristics.

Significant results of the Study are:

1. Each SISS-U.S. Advanced Science subgroup, Biology, Chemistry, or Physics, had a mean science score below the international mean for the respective test.
2. Across subgroups, the best predictor for SISS-U.S. Advanced Science student achievement was student ability as determined by scores on the SISS Mathematics and Word Knowledge Tests.
3. SISS-U.S. Advanced Science students taking an Advanced Placement (AP) science course had significantly higher mean science scores than students in non-Advanced Placement courses. Furthermore, AP students who had studied at least three years each of science and mathematics had mean science scores that were not significantly different from the international mean scores for the respective tests.

4. Three other student factors associated with high SISS-U.S. Advanced Science achievement were common to all subgroups: amount of physical science studied (grades 9-12), interest in science, and attitude toward science. The amount of physical science studied was most significant for the SISS-U.S. Advanced Biology subgroup.
5. The minimum numbers of years of science or mathematics required for graduation from high school, time spent on science homework, and student aspirations for future education and career were not significantly correlated with SISS-U.S. Advanced Science student achievement.

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CHAPTER I

PROBLEM AND SIGNIFICANCE OF THE STUDY

Introduction

Recent national studies and reports have indicated concern for the condition of educational achievement in the United States. A common feature of these reports in relation to educational achievement has been the emphasis on the decline of the United States in science research, technology and economics. Concern has been focused on the implication of low achievement on the maintenance of a "pipeline" for the education and training of scientists and engineers for the 1990s and beyond.

Among these have been studies and reports which cite declining achievement scores on the College Board Scholastic Aptitude Tests (SATs), on College Board Achievement Tests in science, and on national assessments in science (Harnischfeger and Wiley, 1976; National Assessment of Educational Progress, 1978, 1979a; Brooks, 1980; Jones, 1980; National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, 1983; National Commission on Excellence in Education, 1983; Heuftle, Rakow, and Welch, 1983).

Outcomes of the educational system in the United States have been compared with those of other industrialized and technologically advanced nations (Jacobson, 1984c; National Science Board, 1985, 1986, 1987; Klein and Rutherford, 1985; Collins, 1985; National Research Council, 1985).

Science achievement and the resultant adequacy of the scientific literacy of the general population has been raised as a concern along with the maintenance of a pipeline for scientists and engineers (Maben, 1980; National Commission on Excellence in Education, 1983; National Science Board, 1985, 1986; National Science Foundation, 1980a, 1980b, 1986). The National Science Board (1985) has reported that there are

> . . . serious problems in precollege science and mathematics education which threaten our economic future and national security and the ability of all citizens to function in a high-technology society . . . many students leave high school without adequate preparation in science and mathematics. . . .Colleges are required to spend large amounts of scarce resources on remedial education in these subjects.[1]

C. W. Tan (1987) has identified four major forces that demand more science education in the schools and increased overall science achievement. First, the erosion of U.S. economic competitiveness in the world economy is marked by increased foreign competition in technology, record trade deficits, a decline in real earnings of American workers, and a stagnant standard of living. Second, there is an ever accelerating growth of technology and information and most citizens lack the ability to comprehend such technology and information. Third, the role of the computer in education has become a field of study for future career plans, as a tool for problem solving, as an aid in English composition and writing, as a means for the orderly and systematic storage, retrieval, and access of data and information, as a means of furthering the advancement and applications in science and engineering, and as a necessity in the development of technologies. Fourth, there is an increasing need for scientific and technological literacy for all students as a prerequisite to a post-industrial, technologically based society.

Morris Tannenbaum, Vice Chairman of the Board of American Telegraph and Telephone has stated ". . . technological changes require an understanding of how these come about and skills for coping with them."[2]
Of particular concern to the present study, preliminary results from the Second International Science Study (SISS) document the decline in science achievement as reported by the United States national studies and reports (Jacobson and Doran, 1985a, 1987; Jacobson, 1984c, 1986). For example, U.S. students studying a second year of a science in Grades 11 and 12 scored only slightly better than U.S. students in their first year of a given science. Additionally, these students scored significantly below the international mean

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[1] National Science Board, Science Indicators, The 1985 Report, (Washington, DC: U.S. Government Printing Office, 1985), p. 25.

[2] Morris Tannenbaum, "What Do We Want Students to Learn?" Paper presented at FORUM '87: Students and Science Learning, National Forum for School Science, Arlington, VA, 20 November, 1987.

scores for biology, chemistry, and physics. Furthermore, the SISS Preliminary Report (IEA, 1988) revealed that U.S. students not studying science in Grade 12 scored no better than students studying science in Grade 9 on a common set of test items.

The findings from the national reports and studies raise questions about national and local science education policies in the United States. Is the science education being offered in the U.S. adequate for the maintenance of U.S. competition in the industrial and economic world markets? Will the general U.S. population have the competency to advise its representatives to the federal, state, and local governments on matters of science related policy such as new biotechnologies, energy alternatives, and waste management? Will the U.S. lose its technological edge to other countries who have made a national commitment to science education? Will U.S. science education suffer from the "Sputnik syndrome" wherein short-term solutions are developed to solve the immediate problems but no long range planning for continuous evaluation is considered? Specifically, why are U.S. precollege students who are studying an advanced science not achieving at levels comparable with students in other industrialized and technologically advanced nations on the international assessments?

The issues of the lack of national uniformity with regard to curriculum, teacher preservice and inservice preparation in science, availability of facilities within schools, and student attitudes toward science have been raised as possible factors contributing to the decline in science achievement (National Commission on Excellence in Education, 1983; National Science Board, 1985, 1986; National Science Foundation, 1980a, 1980b, 1986).

Another factor may be a general apathy regarding the scientific and technological changes that have occurred in the past 30 years (Tan, 1987; Tannenbaum, 1987). If such apathy exists, what factors have contributed to its development?

Data from international and national studies in science education, such as the First and Second International Science Studies (FISS and SISS, respectively) and the National Assessment for Educational Progress (NAEP), offer policymakers valuable information for assessing and comparing conditions in education across nations as well as within nations. The United States cannot ignore the fact that its very existence as a leader and competitor in business, industry, science research, and technology depends on the education afforded its people and their achievement in the educational opportunity.

That the U.S. advanced science students scored below the international means on science subject achievement tests and that U.S. science students in general have shown an almost unbroken twenty-year decline in achievement on national assessments and on College Board SAT and Achievement Tests is strong evidence that science education is in need of in-depth evaluation and reform. Science education should have top priority at all levels of national and local responsibility.

The present study will provide policymakers with information regarding the identification of school factors associated with high levels of science achievement in an international context. That the factors are not restricted to a single national or small group of nations is significant for global perspectives in science education.

Since the set of school factors related to achievement is subject to control by the school community, this is an area worthy of serious reflection and action by school policymakers.

Statement of the Problem

The major purpose of this study was to determine the level of achievement of United States advanced science students in an international context. A second purpose was to identify school factors which affect the science achievement of United States Advanced Science students.

SISS data used in this study included students' scores on science content tests as well as responses on student, teacher, and school administrator questionnaires.

In this study, the following are investigated:

1. Achievement in a given science subject of U.S. students taking an advanced level course in that science;
2. Identification of teacher factors associated with advanced science students achievement in the United States;
3. Identification of school factors associated with advanced science student achievement in science in the United States;

Implications were drawn for science education policy in the United States regarding science curricula, school structure and organization, and science teacher preservice and inservice preparation.

Setting of the Study

The setting of the present study was within the purposes and structure of a project entitled the "Second International Association for the Evaluation of Educational Achievement Study." This global project was one of the largest international studies in education to date. The science part of this study, one of six content areas studied, is known also as the "Second IEA Science Study" or as the "Second International Science Study (SISS)." Initially headquartered at the Australian Council for Educational Research (ACER), the project was guided by the International Coordinator, Dr. Malcolm Rosier.

The International Association for the Evaluation of Educational Achievement (IEA) is an independent organization of international educational research institutes. Established in the 1950s, its primary function has been to conduct cross-national studies of educational systems using strategies developed cooperatively by member nations. Data have been published on comparative education in subjects such as Science, Literature, Reading Comprehension, French and English as Foreign Languages, Mathematics, and Civic Education.

The Second IEA Science Study (SISS) was begun in 1980 and was patterned after its predecessor, the First IEA Science Study (FISS). FISS was conducted between 1966 and 1971 and has been described in *Science Education in Nineteen Countries* (Comber and Keeves, 1973).

The United States and nine other countries (Australia, England, Finland, Hungary, Italy, Japan, the Netherlands, Sweden, and Thailand) have participated in both FISS and SISS. Such participation provides opportunities for longitudinal studies of science achievement from 1966-71 to 1980-86. It also provides for the identification of relationships between educational practice and changes in social, political, and economic aspects of society.

Funding for the national components of the IEA studies was provided by the individual countries. In the United States, Phase I, which encompassed the first four years of involvement, was funded by the Spencer Foundation. Phase II has been supported by a grant from the National Science Foundation.

Representatives of member nations attended annual meetings of the IEA General Assembly to discuss mutual concerns and to plan strategies for the following year. National Committees within each member country guided the individual nation's participation in IEA studies. The National Research Coordinators (NRCs) held periodic meetings of the respective National Committees when the needs, time, and resources of the participating nations permitted.

The United States National Committee for SISS was composed of 11 members who represented a wide range of experience and expertise. Among the members of this Committee were scientists, science supervisors, science education researchers, science educators, and experts in survey research.

Individual case studies of science curricula have been produced by all SISS nations. It has been the intention of the International Coordinator, Dr. Malcolm Rosier, to publish the information compiled from the various case studies. The "United States Curriculum Case Study" has been published in *An Analysis of Science Curricula in the United States* (Miller, 1986).

In the United States, SISS studies which focus on specific aspects of science learning have been conducted. Included are *Analysis and Comparisons of Science Curricula in Japan and the United States* (Jacobson, W. J., et al., 1986), *Science Achievement in the United States - A Report to the Public* (Jacobson, W. J., and Doran, R. L., 1988), "Science Process Learning" (Kanis, I. B., 1988), "The Teaching and Learning of Physics in the United States" (Chandavarkar, M., 1988), "Sex and Achievement" (Humrich, E., 1988), "The Teaching and Learning of Chemistry in the United States" (Menis, J., 1987), "The Learning of Biology in the United States" (Anderson, O. R., 1988), as well as the present study on advanced science student achievement.

Limitations of the Study

The study was limited to an investigation of students, teachers, and schools in the United States with respect to:

1. advanced science student achievement on science content tests in biology, chemistry, and physics;

2. advanced science student characteristics and behaviors associated with science achievement;
3. teacher characteristics and behaviors associated with science achievement;
4. school characteristics associated with science achievement.

The major intent of SISS was to allow comparisons within and across national educational systems. Some countries have chosen to conduct studies specific to internal policies for local analyses in addition to the international comparative studies and in so doing made optional changes in the SISS instruments. This study was limited in its scope of investigation by the nature of the data obtained from the SISS instruments since SISS-U.S.A. had made changes in the questionnaire items for students, teachers, and school administrators and in the science achievement tests. These changes involved deletion of some international items and subsequent replacement with or addition of U.S. national option items. The indicated rationale for such changes was the basis of extensive field trials, appropriateness to the U.S. populations being tested, and usefulness of the information to be obtained for U.S. science educators.

In all participating countries, questionnaire information was self-reported by students, teachers, and school administrators and as such was a potential source of bias in subsequent analyses.

Additional limitations were imposed by the nature of the SISS study and data. These limitations included:

1. the use of a "paper and pencil" test as the sole means of determining science achievement in the advanced science subjects;
2. achievement scores based on 25 items common to all countries for the Biology and Chemistry tests and on 26 items common to all countries for the Physics test; reduction in the total number of items used for analysis of achievement scores affects reliability of the test instrument;
3. undetermined effects of the translation of test and questionnaire items from the original English to the language(s) of instruction of the participating countries; after having been written by an international committee, the tests were composed in English by staff at ACER in Australia; there were undetermined effects for those countries with English as the language of instruction because of variations in vocabulary and syntax within the English language;

4. ambiguity of quantitative information for the response choices on the student and teacher questionnaires regarding opinions and frequencies of science class activities: depending on the items, choices offered were "frequently," "often," "sometimes," "occasionally," "never," "rarely," "very important," "of some importance," "of little importance," and "of no importance," with no clarification given of what each choice represented in terms of actual time or degree of significance;
5. the use of intact classes rather than the selection of randomly selected students; using intact classes for the advanced science students reduces expected variance for between student analyses since students in the same class have a greater likelihood of having similar backgrounds than would students in different classes;
6. a small sample of SISS-U.S. Advanced Science students compared with the total U.S. population of students in precollege secondary school;
7. a small sub-sample for each of the SISS-U.S. Advanced Science populations, biology, chemistry, and physics, compared with the total U.S. population of advanced science students in each science;
8. undetermined variance in science background of students involved in the testing due to differences in scope and sequence in science curricula among the participating schools

This study did not compare the science subject content or the presentation, for example, visual aids, sequencing of topics, spatial arrangement, and print quality, of the individual SISS test items with similar test items which have been included in various standardized science examinations such as the College Board Achievement Tests in Biology, Chemistry, and Physics.

This study focused on those factors and characteristics of students, teachers, and schools which can be controlled and/or modified by the school community, i.e., the school administrators and teachers. Factors and characteristics of student home background such as sex, levels of parental education and occupations have been presented for descriptive purposes only and have been statistically controlled in analyses. Similarly, factors and characteristics of schools and teachers which are not readily changed by the school community such as location of the school, area population, financial support for the purchase and maintenance of buildings, equipment, and salaries of instructional personnel, teacher sex, age, educational background, and teaching experience have been presented for descriptive purposes and have been statistically controlled for analyses.

It is a premise of this study that a school community can work within a given community, school budget, and with student and teacher populations as they exist to improve the conditions of science learning and the levels of science learning outcomes.

Hypotheses

Based on available literature regarding learning theories, the application of those theories in formal educational environments, and the results of other large scale surveys of science achievement, the following hypotheses were formulated and tested. Literature sources for the hypothesis direction have been cited.

Achievement on SISS Tests

1. On the respective science tests, SISS-U.S. Advanced Science students scores are significantly below the international mean score for each test (Jacobson and Doran, 1987).
2. Across science subjects, SISS-U.S. Advanced Science student achievement scores on the Mathematics Test of the SISS testing program are significantly and positively correlated with student science achievement scores (McDuffie and Bruce, 1980; National Institute for Educational Research, 1985; Keys, 1987).
3. Across science subjects, SISS-U.S. Advanced Science student achievement scores on the Word Knowledge Test of the SISS testing program are significantly and positively correlated with student science achievement scores (Neie, 1972; Keys, 1987).

Factors Associated With Achievement

1. Across science subjects, the same student, teacher, and school factors are associated with high science achievement (Comber and Keeves, 1973).
2. Across science subjects, SISS-U.S. Advanced Science student achievement scores are positively and significantly correlated with student aspirations for future education and career, and with attitudes toward science (Edwards and Wilson, 1961; Keeves, 1972; Comber and Keeves, 1973; McDill and Rigsby, 1973; National Assessment of Educational Progress, 1978, 1979b; Coleman et al., 1981; Heuftle et al., 1983; Tamir, 1986).
3. Across science subjects, SISS-U.S. Advanced Science student achievement scores are positively and significantly correlated with the amount of time spent by advanced science students on science homework (Keeves, 1972; Walker, 1976; Coleman et al., 1981; Walberg et al., 1985; Tamir, 1986).
4. SISS-U.S. Advanced science student achievement scores are positively correlated with science teacher preparation in science, reading of education and science journals, participation in inservice programs, and membership in science teacher or science associations (Comber and Keeves, 1973; National Institute for Educational Research, 1985; Keys, 1987).
5. SISS-U.S. Advanced Science student achievement scores are positively correlated with science and mathematics requirements for graduation from high school (Brookover and Lezotte, 1979; Rock et al., 1985).
6. SISS-U.S. Advanced Science student achievement is not significantly correlated with science class size (Keeves, 1972, 1974, 1976; Ward, 1975; Walker, 1976; Shapson et al., 1980; Keys, 1987).
7. SISS-U.S. Advanced Science students who have taken more physical science courses than biological science courses will have significantly higher science achievement scores on the SISS specialist tests than SISS-U.S. Advanced Science students who have taken more biological science courses than physical science courses (Tamir, 1986).
8. SISS-U.S. Advanced Science students whose science teachers frequently or often evaluate homework will have significantly higher science

achievement scores than SISS-U.S. Advanced Science students whose teachers do not evaluate homework frequently or often (Berliner, 1985; Elawar and Corno, 1985; Walberg et al., 1985).

Basic Assumptions

It has been assumed that

1. the SISS instruments are valid instruments with which to measure science achievement and attitudes;
2. the sample of U.S. Advanced Science students, teachers, and school administrators who responded to the SISS instruments are representative of the population of advanced science students, teachers, and school administrators in the United States;
3. the U.S. Advanced Science student achievement scores on the SISS instruments are distributed normally.;
4. there are correlations between measured "school," "teacher," and "student" factors and SISS-U.S. Advanced Science student achievement as determined by the SISS survey and test instruments.

The identification of school factors most closely associated with SISS-U.S. Advanced Science student achievement will be helpful in the development and improvement of science curricula in the United States. The findings of this study will be helpful to policymakers in the design of long range goals and objectives for science education, Grade K through university.

Educational Significance

Currently there is widespread interest in the quality of education, and of science education in particular, in the United States and other countries. For example, the National Science Board (1986) has reported that numerous national study groups, such as the American Chemical Society, the Association of American Colleges, the National Institute of Education, and the National Research Council together with National Science Foundation advisors and leaders from government, industry, and the academic community have identified deficiencies in the quality of precollege and undergraduate education in the United States. The National Commission on Excellence in Education (1983) has cited several indicators of deficiencies in the U.S. educational systems such as the decline in College Board SAT and achievement test scores, the decline in science achievement scores of 17-year-olds as measured by national assessments in 1969, 1973, and 1977, and the 72 percent increase in remedial mathematics courses in public four-year colleges between 1975 and 1980. Reports from business leaders contain complaints about millions of dollars having to be spent on remedial education and training programs in basic skills such as reading, writing, spelling, and computation (Kearns, 1988).

Science education in the United States received national attention and investment during the 1960s. This emphasis waned during the early 1970s as the need for continued focus was no longer widely perceived and/or acted upon. During the past few years, several national reports of education in the U.S. have raised concerns about the levels of science achievement and the underlying quality of science education. There has also been an increase in interest in the implications of science achievement for the development and maintenance of high technology industries and economic competitiveness. These increases have been cited among the major factors influencing the recent changes in attitudes toward science education. The demand for highly skilled competent workers in new fields is accelerating. Computers and computer-controlled equipment are now components of our everyday lives.

Technology is radically transforming occupations such as health care, medicine, food processing, construction, energy production, and the design, building, repair, and maintenance of sophisticated equipment for educational, scientific, industrial, and military applications. Other factors include concerns about the environment, conservation of energy resources, as well as published studies of comparisons of educational systems in other countries with those in the United States.

Recent data are important to educational policymakers at all levels because of the rapidly changing technological and economic world environment in which this generation of students and those of the future must compete. In addition to having recent reports of achievement scores, information concerning the factors associated with achievement is helpful in the analyses of present curricula and in the development of future programs--

particularly if those factors can be developed and implemented in educational systems with existing personnel, facilities, and resources.

It is hoped that the results of this study will provide information that is both of interest and of use to those who are responsible for the development and implementation of science education policy, programs, and curricula, especially at the precollege levels in the United States.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

A number of studies have been conducted which focused on student academic achievement at the secondary level, and/or in specific science subjects, and on factors associated with that achievement.

This chapter is divided into two sections. The first section presents reviews of selected international and United States national studies and reports which have focused on achievement in science of precollege students.

The second section presents reviews of selected international and United States national studies and reports which have examined factors identified as being associated with science achievement of precollege students. These factors include, but are not limited to, sex of student, family socioeconomic status, the kind of educational program in which the student is placed, time allocation for science instruction, teacher training, retentivity of the school, homework, prior science learning of the student, and aspirations of parents and school for the student.

Student Achievement in Science

International Studies

Three international reports have been reviewed. The first study in this section focused on student achievement in science across an international sample of precollege students. Data presented indicate significant differences in science achievement among participating countries. The second report offered an analysis of the United States results from the First International Study. The third study presented some preliminary results of the United States participation in the Second International Science Study.

First International Science Study. Comber and Keeves (1973) reported on science education in nineteen countries that participated in the First International Science Study (FISS). FISS was part of a larger study, covering Science, Literature, Reading Comprehension, English and French as Foreign Languages, and Civic Education conducted by the International Association for the Evaluation of Educational Achievement (IEA).

Three populations were selected for subject matter testing and questionnaire data: Population I, 10-year-olds; Population II, 14- year-olds; and Population IV, those students in the terminal year of full-time secondary education programs that were either university preparatory or programs of the same length. Population II was of special interest because it was the last age in which schooling was officially required in all of the participating countries. It was also an age for which instruction was given by teachers who were specialists in subject areas rather than by general classroom teachers.

Participating countries in FISS also had the option of studying a fourth group, designated as Population III, which would consist of a nationally selected set of students in some other grade or level between Populations II and IV. Since testing at Population III was a national option, the data are not presented in this review.

Two different types of questionnaires were developed to obtain information which would aid the researchers in determining factors associated with student test scores on the science achievement tests.

Special questionnaires or sections of questionnaires were completed by students, teachers, and school principals. These questionnaires contained items to elicit information about policies and practices concerning the teaching and learning of the subject, organization and scheduling of classes and study time, and attitudes toward various aspects of the subject matter.

General questionnaires were administered to students, teachers, and school principals. These questionnaires were designed to obtain information about students' personal characteristics and family backgrounds, teachers' training and other personal characteristics, general teaching practices, and organizational patterns of the school. The results of these questionnaires are discussed in the section on Factors Affecting Science Achievement.

Subject matter tests were administered to students in the three population levels, Populations I, II, and IV. The Science tests were multiple-choice achievement tests with a number of "anchor items" common to the Population I and II tests and another set common to the Population II and IV tests. These anchor items were included to determine differences in performance from one educational level to another, identified as growth scores in science achievement.

The growth scores in science achievement based on student responses on the anchor items from Population I to II, from Population II to IV, and from Population I to IV were examined. Among the sixteen countries who tested from Population I to II, only three countries, Belgium (Fr), Finland, and Italy, had lower growth scores than the United States. Among the seventeen countries who tested from Population II to IV, only one country, India, had a lower growth score than the U. S. The U. S. had the lowest growth score among the fifteen countries who tested from Population I to Population IV.

Comber and Keeves (1973) examined student achievement scores in regard to those variables which have been shown to be associated with achievement, e.g., opportunity to learn, holding power or retentivity, student background variables, school variables, and teacher variables. These results are discussed in the section on Factors Affecting Student Achievement.

First International Science Study - U.S.A. Wolf (1977) analyzed the United States results in the FISS. For overall science achievement at the Population IV (17-year-olds), the United States ranked fourteenth from the top of the eighteen countries who tested this population. However, Wolf hypothesized that these results do not take into account the differential proportions of the age group still in school at the Population IV level. An estimate of performance of the top 9% of the age group for Population IV was presented. These results indicated that the United States ranked seventh from the top of the eighteen countries in the sample.

Wolf (1977) cautioned that there is considerable variation in the amount of opportunity afforded students to learn the material included in the test. A group of teachers in each school in the testing sample met and rated each item in the test according to a rating scale:

1. None of the students in the appropriate age (or grade) group has studied the topic embodied in this item.

2. Fewer than 25% of the students in the appropriate age (or grade) group have studied the topic embodied in this item.
3. Between 25% and 75% of the students in the appropriate age (or grade) group have studied the topic embodied in this item.
4. More than 75% of the students in the appropriate age (or grade) group have studied the topic embodied in this item.
5. All the students in the appropriate age (or grade) group have studied the topic embodied in this item.

This rating was done separately at each population level. From the rating data, a national opportunity-to-learn (OTL) score was obtained for each school by summing across items. The school OTL scores were then aggregated to determine an overall OTL rating for each country at each population level. As shown in Table 1, the relative standing of the United States in opportunity-to-learn and in science achievement is quite close at all populations. The rank order correlations of OTL with achievement given across countries were +.51, +.75, and +.36 for Populations I, II, and IV respectively. Wolf interpreted this correlation as an indicator that in those countries where students had greater opportunity-to-learn what was included in the test achievement scores were higher.

Table 1

United States Rank Order in Opportunity to Learn and Science Achievement at Populations I, II, and IV

Population	Rank Order of U. S. in		Number of Countries Testing and Rating of Opportunity-to-Learn
	Opportunity to Learn	Science Achievement	
I	1	4	1
II	6	7	16
IV	13	14	16

Source: Wolf, R. M. (1977). Achievement in America. New York: Teachers College Press, Columbia University, p. 40.

Comparing Population I with Population II, the relative standing of the United States decreases for both opportunity-to-learn and achievement. Wolf's interpretation of these decreases is that there is an increasing divergence between the material on the test and what students in the U.S. are learning in science as well as the test performance of the U.S. students. At Population IV, Wolf attributes the rather low standing of the U.S. on both opportunity to learn and achievement to both the lack of selectivity within the student population and the relative lack of specialization in science by the students. A lack of focus of the science curriculum in the U.S. due to the decentralized educational system may also be a factor in the OTL and achievement score ranking of the United States in the international setting.

Second International Science Study - U.S.A. Jacobson and Doran (1987) reported some of the preliminary results for the United States participation in the Second IEA Science Study (SISS). The testing was conducted in two phases. In Phase I (1983-84) four populations were tested: Population I (5th Grade), Population II (9th Grade), and two groups at Population IV (12th Grade): 12th Graders studying physics and 12th Graders not studying science. The students in these populations were given a core science test appropriate for the age or grade level. The core tests contained items on biology, chemistry, physics, and earth science. In addition, the Population IV physics students were given a specialist test in physics.

In Phase II (1986), populations not included in 1983-84 were tested. These populations included: students in first-year courses of biology and chemistry; students in second-year (advanced) biology, chemistry, and physics. The students in second-year science courses were given science content achievement tests for the science subject in which they were enrolled. These tests almost exclusively used items developed by international representatives of the IEA for use in all participating countries. A few items (five items each in Biology and Chemistry, and four items in Physics) were eliminated from the international set of questions because their content was not included in United States second-year or advanced science curricula. Such items were replaced by SISS items from the Grade 12 core test and/or the Grade 12 nonscience test.

A feature of the study was the use of bridge items, which were common to both SISS and the earlier FISS. On bridge items, Grade 5 scores in SISS showed "no change to slight growth" when compared with FISS Grade 5 scores. Grade 9 scores on bridge items in SISS showed "no change to slight decline" when compared with FISS Population scores. Grade 12 physics students in SISS scored slightly better than their cohorts in FISS. Grade 12 nonscience students in SISS scored "no differently" than their FISS cohorts.

Another feature of the study was the use of anchor items which were questions common to tests at different population levels. On average, Grade 9 students had higher scores on the anchor items by 19% than students in Grade 5. Grade 12 physics students achieved 22% higher scores than students in Grade 9 on the anchor items. Nonscience students in Grade 12 had the same mean score as students in Grade 9.

The preliminary comparisons with students at Population IV level across countries indicate U.S. students in a second-year or advanced science course consistently performed at lower levels than students in the other participating countries (Table 2). These mean score levels ranged from 10% to 30% lower than the mean scores of students in other countries.

Table 2

Preliminary SISS Comparisons of U.S. Results With Japan, England, and an International Composite for Population 3 Students (Percent Correct)

Country	BIO	CHEM	PHYS
U.S. 2nd Year	44	41	44
Japan	48	62	59
England	71	73	58
Int'l Composite (9 countries)	62	55	51
Number of Items Common to All Countries	25	25	26

Source: Jacobson, W. J., and Doran, R. L. Preliminary Results for the U.S.A. Participation in the Second IEA Science Study - 1987.

United States National Studies

Studies and reports reviewed in this section examine student achievement in science at the national level in the United States. The primary focus in these studies is on those students enrolled in precollege science in secondary schools.

National Assessment of Educational Progress (NAEP): Three Assessments of Science. The National Assessment of Educational Progress (NAEP) conducted three assessments of science: 1969-70, 1972-73, and 1976-77 (1979a). The populations sampled were students of ages 9-, 13-, 17-years-old, and young adults ages 20- through 25-years-old.

Each NAEP assessment used a stratified, multistage probability sample design to insure adequate representation of the actual population of students within the designated age groups. The Reports summarize changes in science performance on exercises included in both the first and second assessments and on exercises included in the second and third assessments. Some exercises were common to all three assessments. With this data available, NAEP was able to measure indicators of improvements and declines in science achievement over a 17-year period. Results reported here are for the 9-, 13-, and 17-year-olds since these age groups are included in the SISS of which this present study is a part.

Between the 1969-70 and the 1972-73 studies, science achievement of 9-year-olds declined significantly on measures tested except for biology. For measures dealing with the affective objective of appreciation of science, there was a significant increase in scores. No overall change was noted in scores between the 1972-73 and the 1976-77 assessments. Achievement in physical science declined significantly while achievement on biology exercises increased by almost two standard errors. The exercises which measured appreciation of science showed a significant increase in scores.

NAEP results for the 13-year-olds from 1969-70 to 1972-73 were similar to those for 9-year-olds during the same time period: there was a significant decline in overall science achievement. The decline in biology scores was not significant, and the scores for the exercises on appreciation of science showed significant increases. On exercises which were unclassified or not designated as being specifically "biology", or "physical science" and were applicable to either biological or physical science, there was a significant decline in scores. Between 1972-73 and 1976-77, there was no overall change in scores, although another significant decline in scores was observed on the unclassified exercises.

Average achievement for 17-year-olds declined on all exercises over the three assessments. The declines in test scores were not significant for biology, the unclassified exercises, or the exercises measuring appreciation. Declines were significant for the exercises in physical science.

Science and Engineering Education for the 1980s and Beyond. The National Science Foundation and the Department of Education (1980) published a report which provided analyses of a number of important and difficult issues facing the science and education systems in the United States. This report reviewed the decline in achievement scores in science and mathematics from the mid-1960s to the late 1970s: the most dramatic drops occurred in the mid- to late 1970s and were most evident in the higher grades. Although the achievement scores on SATs for students planning majors in science and/or mathematics were much higher than those scores for students planning nonscience careers, the broad assessment of the science and mathematics achievement of all high school students showed considerable decline since the early 1960s. Other industrialized countries, including Great Britain, France, Japan, West Germany, and the Soviet Union, have placed considerable importance on mathematics and science education and have developed plans to attain high levels of competency in the general population.

Factors cited in the report as being associated with the decline in achievement scores of students in the United States include:

1. A discrepancy exists in the amount of science and mathematics training and skill acquired by students who intend to enter science-related careers and those who do not; students who intend to enter science-related careers are learning as much science and mathematics as they ever did; however, students who do not intend to enter science-related careers are ending their study of these subjects at an increasingly early stage and are performing less and less well on achievement measures.
2. There is an apparent reinforcement of this discrepancy by a general lowering of standards and expectations of student performance and of admissions requirements by colleges and universities.
3. There is an apparent mismatch between course content and the needs and interests of the large number of students who do not plan on science-related careers.
4. There is a shortage of mathematics and physical science teachers and an erosion of teacher support systems.

Science Assessment and Research Project (SARP). Heuftle et al. (1983) presented and analyzed student responses to science content and attitude items in a 1981-82 study conducted by the Science Assessment and Research Project (SARP), University of Minnesota. The researchers indicated that the purpose of SARP was to fill the void in national science assessments between the 1976-77 assessment in science by the National Assessment of Educational Progress (NAEP) and the next NAEP science assessment at a date then undetermined due to political decisions and financial restraints. According to the authors, it was felt by many science educators that during the NAEP hiatus emerging problems would go unchecked (Heuftle et al., 1983).

The 1981-82 SARP national assessment, using 1976-77 NAEP items, tested a national random sample of 18,000 9-, 13-, and 17-year-old students enrolled in public or private schools who were neither in institutions nor too functionally handicapped to respond to assessment exercises. The testing domain consisted of four main areas:

1. Science Content: biology, physical science, earth science, and integrated science topics;
2. Science, Technology, and Society: persistent societal problems, science and self, and applied scientific technology;
3. Inquiry: science processes and decision-making;
4. Attitudes: science activities and attitudes towards science classes, science teachers, science careers, the value of science, and socioscientific responsibility.

For the populations of students in the middle and secondary school grades (ages 13 and 17), the SARP achievement score results continued to decline from the 1977 scores which had in turn declined from the 1969-70 scores. The rate of decline from 1976-77 to 1981-82 was not as great as it had been in previous assessments. The overall data change showed a leveling off of the decline in science achievement in the Science Content area from 1977 to 1981. One explanation for this leveling off proposed by the authors was that some individual item score changes may have been influenced by the attention given to specific topics by the media such as public television science programs on ecology.

The biology achievement scores for 13-year-olds increased from the 1972-73 assessment scores and in 1981-82 showed +1.3% overall increase relative to the 1969-70 scores. There was no similar increase noted for the biology achievement scores for the 17-year-olds, however. Science achievement scores continued to decline in both biology and physical science. The physical science achievement for 17-year-olds was 6.3% below what it was in 1969.

Since similar declines in scores were observed for the other areas tested, one implication for the declines offered by the authors was that perhaps young adults lack needed scientific knowledge to face complex technological problems and therefore they feel less certain that such problems can be solved by anyone.

Section Summary

The FISS, SISS, NAEP, and SARP show that, with few exceptions, there has been a general decline in student achievement in science in the United States during the last 20 years, especially in the physical sciences. In addition, when compared internationally, science achievement scores of students in the United States have not been among the top scoring countries.

Results from the First International Science Study showed the United States having the lowest growth score among the fifteen countries who tested from Population I (10-year-olds) to Population IV (17-year-olds). The overall achievement of U.S. students in Population IV ranked fourteenth from the top of the eighteen countries who tested this population. However, a closer analysis of the top 9% of the age group for Population IV showed that the United States students ranked seventh from the top of the eighteen countries. A correlation of opportunity-to-learn with achievement score indicated that the relative standing of the U.S. in opportunity-to-learn and in science achievement is quite close at all populations. The interpretation given is that in those countries where students had greater opportunity to learn what was included in the test, achievement scores were higher.

The preliminary results of the Second International Science Study indicate little change in the achievement of U.S. students relative to other countries from the results of FISS 13-16 years ago. Growth scores (modal grades for each population) between students in Grade 5 and those in Grade 9 (10-year-olds and 14-year-olds, respectively) showed 19% higher scores for students in Grade 9 compared with students in Grade 5. Grade 12 physics students achieved 22% higher scores than students in Grade 9 on anchor items in core science tests. However, nonscience students in Grade 12 scored the same as students in Grade 9 on the anchor items in the Grade 12 nonscience core test. When compared internationally, the preliminary scores indicate that the U.S. students in a second-year or advanced science course scored consistently lower than their cohorts in other countries--as much as 30% lower in some instances. United States nonscience students also scored lower than their cohorts but the margin was only about 10% on average.

National studies in the United States have indicated a steady decline in student achievement in science. The National Assessment of Educational Progress conducted three assessments in 1969-70, 1972-73, and 1976-77. The science achievement scores of 9-, 13-, and 17-year-olds declined over the three assessments. The decline in scores was greater in physical science than in biology. However, on items which measured an appreciation of science, there was an overall increase in scores for the three populations of students over the three assessments.

The National Science Foundation and the Department of Education report reviewed the decline in science and mathematics achievement scores from the mid-1960s to the late 1970s. The most dramatic drop in scores occurred during the mid- to late 1970s and was most evident in the higher grades. The report commented upon the importance placed on science and mathematics education by other countries, notably Great Britain, France, Japan, West Germany, and the Soviet Union.

The Science Assessment and Research Project, conducted to fill the void between the 1976-77 NAEP science study and the next NAEP study, showed a continued decline in science achievement scores for students ages 13 and 17. However, the rate of decline from 1976-77 to 1981-82 was not as great as it had been in previous assessments. In fact, overall change data showed a leveling off of the decline for all ages in science achievement scores from 1977 to 1981.

Factors Affecting Science Achievement

Factors which affect student achievement include those variables over which schools have no control as well as those over which they have some control. Student gender, socioeconomic status (SES) of the student's family, and the community in which the student lives are included among those factors over which a school has no control.

Factors affecting student achievement and over which schools can exert influence and which have been shown to be alterable include the type of school and/or educational program in which the student is placed. Within the school-related set of factors are the characteristics of the curricular and instructional policies, organizational patterns of the school itself with regard to scheduling of classes, provision for opportunity to learn within the classes, provision of models for educational and career aspirations of the students, and for competent teachers who are well-trained and interested in the educational process.

This section is divided into subsections according to the blocks of variables which have been selected for analysis in the present study. Each subsection is further divided with respect to the variables being considered. Relevant studies and reports are reviewed in each division of each subsection.

Student Background

Students enter school with certain characteristics unalterable by the educational system. These characteristics include, but are not limited to, gender, family size, and socioeconomic status of family.

Sex. Comber and Keeves (1973) reported that science achievement of boys was higher than that of girls, and that the difference between the sexes increased with the age of the students. Explanations for the difference in science achievement between boys and girls appear to focus on the apparent lack of science and science-related experiences made available to girls during their early childhood. Attitudes of students toward science were noted to be positive across the populations with boys tending to be more positive than girls, especially in Populations II and IV.

Similar results were reported by Kelly (1972a), Keeves (1972), McDill and Rigsby (1973), Husen et al. (1974), Schmidt and Kifer (1986), the National Assessment of Educational Progress (NAEP) (1978, 1979), and Hueftle et al. (1983).

Socioeconomic Status (SES). Edwards and Wilson (1961) identified socioeconomic status (SES) as a variable in predicting success in schoolwork. The study involved 4,500 high school students from the San Francisco Bay area in the United States and 900 secondary students from London, England. They found that children selected for advanced educational opportunities on the basis of their prior achievement showed orientations that associate with membership in upper SES. These findings are supported by Schneider et al. (1979) who found that SES is a dominant factor of achievement in schools that select students for admission on the basis of academic achievement. Tamir (1986) reported SES as a factor in student success in physics and, overall, is a more global determinant of achievement than the effects of prior learning.

Comber and Keeves (1973) noted that, in general, at the upper secondary school level where school becomes highly selective, home circumstances usually cease to be significant except that this more homogeneous student group is formed with students from more advantaged homes. Personal and social backgrounds of students were reported to be influences in the students' achievement in and attitudes toward science. Similarity in students' backgrounds was noted to be a factor in achievement. For example, students whose fathers held professional or managerial positions were found to group together in schools with other students whose fathers were of similar occupational status levels. It was further noted that the correlation between occupational status of the father and student science achievement was greater when the school was the unit of analysis than when the student was the unit of analysis.

Coleman et al. (1981) implied SES as a factor of achievement in his study of public, Catholic, and other private schools in the United States. Students in the Catholic and other private schools were shown, on average, to achieve at higher levels than students in public schools. Since parents pay tuition for Catholic and other private school education, the average SES of the families of students attending those schools is assumed to be higher, in general, than that of students attending public schools. The study also included comparisons of high-performance public and private schools and similar results were found in that students in high-performance private schools outscored students in high-performance public schools.

School Characteristics

School characteristics include, but are not limited to, the type of school (i.e., comprehensive, magnet, technical/vocational), the existing conditions of learning (i.e., the learning environment), the sex composition of the school, attitudes and aspirations of the school for the students, organizational pattern of the school regarding scheduling of classes, time allocation for classes, the nature of the science curriculum (i.e., integrated or differentiated science), retentivity of the school, opportunity-to-learn, homework, and facilities.

Type of School or Program. Schools vary in the kinds of educational programs offered to students. One school may specialize in academic programs. Another school may focus on vocational and/or technical education. Still another school may offer both kinds of educational programs. Within each program there may be still further differentiation. For example, within an academic program, there may be tracks which emphasize the arts and humanities, the biological and/or physical sciences, and mathematics.

Comber and Keeves (1973) observed two patterns among those countries which had a high proportion of students studying science (Australia, Belgium, Chile, Federal Republic of Germany, Finland, Hungary, New Zealand, and Thailand). One pattern identified was one in which students were normally expected to study some science and therefore studied general science at first and then selected one or more branches of science in later years of secondary school. A second pattern was one in which integrated science was developed and introduced in the secondary school grades and continued to the pre-university grade.

Coleman et al. (1981) noted that student placement in a particular program was a potential determinant of subsequent achievement and that it also was an indicator of past achievement and of future intentions. He reported that students in Catholic and other private schools tended to be placed in academic programs rather than in general or vocational programs. As noted previously, the overall achievement levels of students in Catholic and other private schools were higher than those of their counterparts in the public schools. It was also recognized that most Catholic and other private schools did not offer general and/or vocational curricula as did most public schools. Students in most Catholic and other private schools are placed in an academic program, not on the basis of the students' ability or interests, but simply because that is the only educational program offered by the schools. If these same students were enrolled in a public school, they might be placed in a general, commercial, or vocational program on the basis of ability and/or interests. Students in a nonacademic program would not necessarily have the same courses as those students in the academic programs, thereby affecting the opportunity to learn the same content.

In a comparison of curricula, Walker and Schaffarzick (1974) also reported that different curricula are associated with different patterns of achievement in the various disciplines such as mathematics and science. For example, two groups of students may study science for two years but one group may take general survey courses while the other group may enroll in courses which present a limited number of topics which are covered in depth. The achievement of the two groups on a general science achievement test would be expected to vary according to the relationship of content emphasis of the test questions and the content presented in the students' science courses.

Wolf (1977) suggested that it is possible that different material is taught in the various U.S. curricula and that the material actually taught is not in some way inferior compared with the content of the test items presented in assessment achievement tests, but rather has different emphases. The correlation of the type of program with achievement was found by Wolf to be +.41. Tamir (1986) also found that the track in which a student was enrolled was positively related to that student's achievement.

In addition, it was found that, with respect to the general policies and practices of the teaching and learning of science, English-speaking countries tended to have a conceptual approach to science teaching with emphasis on laboratory work and practical experiences (Comber and Keeves, 1973). In contrast, the continental European countries relied on a strong theoretical grounding in science with less emphasis on investigation and/or inquiry.

Conditions of Learning. There are several characteristics of schools which comprise the learning environment and provide the students with various conditions under which learning may or may not occur. Among these characteristics are the sex composition of the school itself, the attitudes and aspirations of the school community for the students, organizational patterns and scheduling of classes, and time allocated for instruction.

Sex Composition of School. Kelly (1972a) reported that achievement of students in either O-level or A-level biology in England was not related to sex composition of a school but that only the differences between girls' schools compared with boys' and mixed schools were statistically significant and then not of great magnitude at either O-level or A-level.

Attitudes and Aspirations of the School for Students. Edwards and Wilson (1961) identified characteristics of schools to be associated with student achievement such as attitudes toward academic achievement, further education, and career aspirations. It was reported that schools tended to reward those students with literary and verbal orientations with greater frequency than those with scientific and qualitative orientations. Students were observed to assume, increasingly, as they progressed through school, the model aspirations of the particular school. The climate of attitudes in a particular school was noted to vary according to the social conditions of the segments of the community from which the school drew its clientele. This implied that the SES of a given segment of the community would imbue the school to which it sent its children with certain attitudes towards education and aspirations for the futures of its students. Similar findings were reported by Comber and Keeves (1973), Brookover and Lezotte (1979), Coleman et al. (1981), and Tamir (1986).

Organizational Patterns of School. Organizational patterns of school including the scheduling of classes and study time have been recognized as influencing student achievement by Comber and Keeves (1973). The patterns of organization varied within countries as well as between countries. In general, there was an increase in the overall size of a school as the students became older. Developing countries had significantly higher student/teacher ratios which remained constant as the students grew older or, as in Iran, increased dramatically after the Population I level. These developing countries tended to have a higher proportion of the total teaching force engaged in teaching science than did the developed countries. In addition, those countries which emphasized individual practical experience in science made attempts to reduce the size of laboratory groups and to provide ancillary help in laboratory classes.

Organizational patterns of classes differed among the participating countries in FISS. In most countries, science instruction was begun by the general classroom teacher, usually during the elementary grades. A few exceptions were noted: Belgium and Chile presented formal science instruction during Grade 8 in which the students leave the general classroom; the Federal Republic of Germany began formal science instruction one year after the students had made the transition to differentiated classes at Grade 6 when different subjects are taught by different teachers.

Schools having a more flexible organization were linked with higher science achievement for Population II as compared with those schools having a rigid climate. Opportunity-to-learn (OTL), i.e., the opportunity for a student to have a learning experience such as a laboratory investigation, was found to be related to the scheduling of classes and to the time allocation for science classes.

The organization and scheduling of classes and study time also have been identified as factors related to school attitudes toward learning and thus have impact on student achievement outcomes (Kelly, 1972b; New York State Department of Education, 1976; Walker, 1976; Weiss, 1978; Edmonds and Fredericksen, 1978; Brookover and Lezotte, 1979; Schneider et al., 1979; Coleman et al., 1981; and Klein and Rutherford, 1985).

Time Allocation for Science Instruction. Comber and Keeves (1973) reported that the amount of time devoted to science at Population I was generally found to be substantial, i.e., in most countries, science instruction was allocated about one-fifth of the total class time. Similarly, the time allocated to science for Populations II and IV was found to be substantial and uniform for most countries and was comparable to the amount allocated for Population I.

In the United States, the average number of minutes per day allocated to science instruction in grades K-6 was 20 minutes compared with 44 minutes for mathematics, 86 minutes for reading, and 25 minutes for social studies (Weiss, 1978). At grades 7-12, the amount of time allocated to science instruction varied among schools depending on the science curriculum offered by the individual schools. Even if time is allocated for science, many students in grades 7-12 have the option of course selection and, unless science is compulsory at a given grade level, students may choose not to study science.

Science Curriculum: Integrated or Differentiated. Most countries favored an integrated science for the first year or two in secondary school (Comber and Keeves, 1973). An integrated science course is one which presents content in both biological and physical science.

Differentiation in curriculum, resulting in tracking of students, occurs in the secondary schools with alternatives and options presented to the students for future study and careers (Comber and Keeves, 1973). This differentiation has been noted to coincide with the point at which science instruction became separated into its major branches within the schools. One result of these differentiations in both curriculum and science instruction has been that different categories of students devote different fractions of their time to the study of science. However, across the national patterns of science instruction for both Populations I and II in the First International Science Study, very few students did not make some contact with formal science learning at school (Comber and Keeves, 1973).

At Population IV in FISS, however, comparisons between countries of proportions of students studying science resulted in the countries falling sharply into two categories with few intermediates (having an intermediate proportion of students): those with high proportions of students studying science, and those with low proportions of students studying science.

Among the group of four countries, England, France, Italy, and Sweden, having a low overall proportion of students studying science, students became more or less specialized in their education and focused on Natural Sciences, Social Sciences, Humanities, or some similar field. Those students who followed curricula in Social Sciences or the Arts and Humanities would most likely not have studied science in the last two or three years of their secondary schooling.

In the United States, which was among the few intermediates, science education was noted to be characterized by horizontal strata following general science courses in Grades 7, 8, and 9 (Comber and Keeves, 1973). The usual pattern appeared to be biology in Grade 10, chemistry and/or physics in Grades 11 and/or 12. This pattern appeared to be primarily due to the fact that student course loads consisted of a number of electives which might or might not have included science. Also, colleges required one or at most two science courses for admission, depending upon the intended major of the student.

Retentivity of School. Retentivity is taken to be the degree to which students of a given age remain in school, or the holding power of a school. For example, in Japan, the upper secondary education, which is not compulsory, enrolled about 93% of the 15- to 17-year-olds (Jacobson et al., 1986).

Retentivity of school systems has been found to be a factor related to smaller growth in achievement and lower mean level of achievement in science between 14-year-olds and 17-year-olds as well as lower overall mean achievement at each population (Comber and Keeves, 1973). Most countries have a lower degree of retention in the upper secondary grades than does the United States, that is, fewer students in the total upper secondary age group remain in school. Like the U.S., Japan has a high retentivity in the upper secondary grades, but the level of achievement of the Japanese students for 17-year-olds is significantly higher than that of the U.S. students (Comber and Keeves, 1973; Jacobson et al., 1986).

With regard to retentivity and its association with science growth scores, a negative linear relationship was observed. This indicated that the greater the holding power for a country the lower the mean level of performance. In examining growth scores from Population I to Population II, and from Population II to Population IV, both against retentivity, the U.S. rank position among the countries at each population was that of having the lowest mean level of growth with the highest degree of holding power (Comber and Keeves, 1973).

Opportunity To Learn (OTL). Opportunity-to-learn (OTL) may be viewed as an outcome of school attitudes and organization since these factors influence curricula which is the usual means of exposure to subject matter for students. OTL can be studied from a historical perspective (prior learning) or from a current standpoint (what is being studied). A given curriculum may indicate that a specific topic is to be presented to the students but not necessarily how it is to be presented or for what length of time. The "how" and "for-how-long" may very well be established at the national, state or local school level, or by the individual classroom teacher. Even the "what" may be decided at the various levels of responsibility. OTL may be provided either formally in a school setting or informally in some context outside of school, such as in media presentations, zoos and museums, youth organizations with science-related activities, and nature centers.

Comber and Keeves (1973) identified a clear linear relationship between OTL and student achievement for 14- and 17-year-olds. In the FISS, Comber and Keeves (1973) found, that for Population II (14-year-olds), the results indicated a distinct positive relationship between performance and opportunity-to-learn. For Population IV (students in the last year of pre-college schooling), the results showed a similar pattern relating performance and opportunity-to-learn. However, the pattern for Population IV, although indicating a positive relationship between the two variables, appeared as two separate but parallel formations. One formation displayed the average scores of the United States and the majority of the countries of Western Europe. The second pattern displayed the average scores of the four developed Commonwealth countries, Australia, England, New Zealand, and Scotland. These four countries had average scores several points above those for the other developed countries when allowance was made for assessed opportunity to learn. The possible explanations given for the differences between the two groups of countries included the nature of the content tested, the manner in which the test items were phrased and constructed. It is also possible that the differences reflect outcomes of a more empirical approach to the study of Science in the Commonwealth countries.

Walker (1976) also found OTL closely linked to student achievement, as did Kelly (1972a), Coleman et al. (1981), and Tamir (1986). The National Science Board (1985) reported that American high school students, on average, took 2.2 years of science during the four years of high school. The 10th grade was noted as being the last time most high school students in the United States are exposed to any science. In comparison, most students in other countries take science every year (Comber and Keeves, 1973; Klein and Rutherford, 1985; Jacobson et al., 1986; and National Science Board, 1983, 1985).

Homework. Time on task is generally regarded as being the time during which a student is actively engaged with a task. This differs somewhat from OTL since a student may very well be exposed to subject matter in class but not be an active participator in the lesson. Time on task may also involve work done outside of school, for example, homework.

The influence of homework on student achievement has been reported by Walberg et al. (1985) in a synthesis of 15 empirical studies of the effects of homework on learning by elementary and secondary school students. Even when homework was merely assigned and no feedback given from the teacher, the typical student at the 50th percentile raised his or her achievement level to the 60th percentile. However, when graded or otherwise commented upon, consistent homework appeared to raise learning levels from the 50th percentile to the 70-79th percentile range on average.

Coleman et al. (1981) reported that U.S. high school students were averaging between four and five hours per week on homework and about 28 hours per week viewing television. Nogami and Jacobson (1986) and Jacobson et al. (1986) reported that Japanese students in high school engage in up to 40 hours of extramural tutoring and study per week in addition to regular school on Saturday. Homework assignments given prior to the six-week summer vacations are presented in the Fall term to the same teacher who had given the assignments at the end of the Spring term.

Similar findings concerning the amount of homework reported to be done and its effects on achievement have been reported by Giddings (1966), Keeves (1972), Walker (1976), Wolf (1977), Coleman et al. (1981), and Tamir (1986).

School Facilities. School facilities, i.e., dedicated science classrooms, laboratory facilities, laboratory assistants, equipment, and textbooks, have been reported as not being related to achievement by the New York State Department of Education (1976), and as being of minimal contribution by Okebukola and Adeniji (1987), and Coleman et al. (1981).

Teacher Characteristics

Teacher characteristics have been reported to be contributors to student achievement in science (Kelly, 1972; Comber and Keeves, 1973; Walker, 1976;

Brookover and Lezotte, 1979; Burrows and Okey 1979; National Science Foundation, 1980; Coleman et al., 1981; Klein and Rutherford, 1985; Tamir, 1986; and Okebukola, 1987). Teacher characteristics that have been identified as being positively associated with student achievement include teacher preparation, graduate education, inservice training, membership in professional associations (for example, the National Science Teachers Association, the National Association of Biology Teachers, and the American Association of Physics Teachers), attendance at and participation in professional association conferences and workshops, interest in and communication with students, participation in curriculum development, and having input to the formation of school science program policy.

Comber and Keeves (1973) reported teacher preparation and its effects on science learning as being difficult to interpret and thus produced no clear conclusions overall. Wide variation was noted with respect to inservice training: the reported average time being of less than one week per year allotted for teachers at Population II and IV age and grade levels. In some countries, however, Comber and Keeves found that teacher attendance at professional conferences was positively related to higher student performance. It was concluded that those teachers who made an effort to learn about changes in science knowledge and in methods of teaching also made an effort to incorporate their upgraded skills into their classroom teaching.

Among teacher characteristics, various teaching methods were included by Comber and Keeves (1973). Frequent use of drill materials was found to be positively related to achievement on FISS academic tests thereby supporting the use of drill activities to raise performance levels. There was little evidence noted to assess the use of inquiry and/or investigation in bringing about higher levels of achievement.

Student Characteristics

Activities, Attitudes, and Interests. Student activities both in school and outside school reflect the attitudes and interests of the individual students and often those of their parents and peers. In some instances, participation in a given activity may be influenced by the sex of those already involved. For example, a girl may have an interest in astronomy and finds that an established astronomy club has a membership that is presently all male. Or, a boy may have an interest in conservation of wetlands in his community and finds that the ecology club which exists has an all-female membership. In both cases, peer pressure may discourage the students from joining the group which shares their individual interests.

Parental attitudes and those of the community in general may also affect the personal attitudes of a student toward education in general, and specifically toward science in similar ways (Keeves, 1972).

Researchers have reported that males are more likely to have favorable attitudes toward science classes, science related careers, and to have had science related experiences and that such attitudes and experiences are associated with higher achievement in science (Edwards and Wilson, 1961; Giddings, 1966; Keeves, 1972; Comber and Keeves, 1973; McDill and Rigsby, 1973; Walker, 1976; Wolf, 1977; National Assessment of Educational Progress, 1978, 1979; McDuffie and Bruce, 1980; Butts, 1981; Coleman et al., 1981; Heuftle et al., 1983; Napier and Riley, 1985; Tamir, 1986; and Okebukola, 1987).

Heuftle et al. (1983) analyzed the results of the Science Assessment and Research Project (SARP) study for 17-year-olds and found that 58.5% of the students had been or were currently engaged in science experiences. Of the total group of students, 48.0% held favorable views toward science classes, 66.0% saw science teachers in a favorable light, 52.0% felt a science career would be worth pursuing, and 62.0% generally valued science. Only one-third of the students in the study thought that their science class was interesting and easy, 82.0% reported being bored, and 72.0% found the classes too difficult. Most students felt comfortable in class but 38% reported being afraid to ask questions. Despite generally low ratings on relevancy of science classes, 75% of the students believed that their science classes were useful. Overall, the SARP data revealed a 1.5% decline in positive attitude toward science from the 1977 NAEP data.

Parent Attitudes and Interests. Parental interest in the student and the student's education, parental aspirations for future education and career of the student, and peer attitudes and aspirations are among the factors identified by researchers as influencing a student's personal attitudes and aspirations.

Such attitudes and aspirations combine to form a basis for the student's self-motivation to learn and attain some level of achievement perceived as necessary for future education and/or employment. Student motivation has been identified as one of the most important factors affecting achievement (Edwards and Wilson, 1961; Giddings, 1966; Keeves, 1972; Kelly, 1972b, 1972c; McDill and Rigsby, 1973; Wolf, 1977; Stake et al., 1978; Weiss, 1978; Ururoglu and Walberg, 1979; Coleman et al., 1981; Heuftle et al., 1983; Napier and Riley, 1985; Tamir, 1986; and Schmidt and Kifer, 1986).

Home background factors such as parents' education levels and occupations, reading/reference resources in the home, and having a place and time to study at home have also been identified as factors strongly influencing student achievement (Giddings, 1966; Keeves, 1972; Comber and Keeves, 1973; Wolf, 1977; Stake et al., 1978; Butts, 1981; Coleman et al., 1981; Heuftle et al., 1983; Tamir, 1986; and Walker, 1986).

Section Summary

There are three major types of factors which affect student achievement:

1. those variables over which schools can exert the most influence such as the type of program available, i.e, academic, vocational, or some combination of academic and vocational; aspirations of the school community for student achievement and career aspirations; organizational patterns of the school regarding scheduling and time allocation for science instruction; the scope and sequence of the science curriculum; opportunity to learn; providing competent teachers; providing adequate facilities and equipment for science instruction; and homework;
2. those variables over which schools have no control such as student sex; student family SES, i.e., parental education levels and occupations, number of books in the home;
3. the community in which the student lives, i.e., metropolitan or nonmetropolitan status; industrialized or agricultural; area population and ethnic composition.

Also noted as factors associated with student achievement are parent and student activities and interests in and attitudes towards science. These are related to parental education levels, occupations, and aspirations for the students, but they are capable of being changed. Additional factors include the activities, attitudes, and interests of the peer group which, in turn, reflect other parents' backgrounds as well as the attitudes of the community at large.

It is interesting to note that these factors which affect student achievement have been identified in international studies as well as in studies conducted within single countries. Despite the differences among countries with respect to geography, politics, ethnicity, resources, educational philosophy, and religions, there are many commonalities to be found across nations within the educational and social systems which appear to be changeable and/or capable of modification for the benefit of all of the students in all countries.

Chapter Summary

Studies on science achievement at the national level have reported a decline in science achievement since the late 1960s. Although there are recent indications that the rate of decline has been leveling off, the decline has been almost unbroken for the past 20 years. The decline has been greatest in physical science and more noticeable in the higher grades. However, despite the drop in science achievement, there has been an overall increase in appreciation or positive attitude toward science.

Among the factors which have been associated with student achievement in science are those over which the school has little or no control. These factors include parent education levels and occupations, parent aspirations for the student, parent attitudes toward school and science, the type of community in which the student lives, student family socioeconomic status, and student sex. Although not under the influence of the school, such factors must be acknowledged as having an effect on the student's performance in school.

There are several important factors over which the school can exert influence and which have been shown to affect student achievement. These factors include the type of school, the kind of educational program in which the student is placed, the curricular and instructional policies of the school, the organizational patterns of the school, the degree to which the school provides the opportunity to learn, models for educational and career aspirations of the students, and competent teachers.

In reviewing the international studies as well as the national studies, there is much commonality across countries regarding factors that affect student achievement. This commonality exists despite differences in politics, geography, religion, resources, ethnicity, and economics among the countries.

Chapter III

DESIGN OF THE STUDY AND PROCEDURES

Introduction

The Second International Science Study-U.S.A. (SISS-U.S.A.) involved the testing of more than 14,000 students in the United States and resulted in a final sample of more than 12,000 students from whom usable data were obtained.

The design of the present study included a three-stage probability sample of 1736 public and private students who were studying a second year (advanced) course in biology, chemistry, or physics in 118 schools across the United States. The SISS-U.S.A. advanced science student sample was compared with 17,534 students studying science in the last year of precollege secondary education in 1091 schools in three selected other countries which participated in the IEA Second International Science Study.

Three structured questionnaires had been developed and sent to the administrators of the schools in which testing was to be conducted, to the teachers of the classes to be tested, and to the students to be tested. Students were given a science achievement test in biology, chemistry, or physics, specific to the course in which they were enrolled. Gathered data were coded and transferred to computer tapes for preliminary analysis and summary by Research Triangle Institute, Research Triangle Park, NC. Analyses for the present study were carried out using the Statistical Program for the Social Sciences-version X (SPSS^{X}) on the DEC-20 mainframe computer at Teachers College, Columbia University. Much of the data analysis consisted of descriptive statistics. Correlation and multiple regression analyses were used to determine relationships between student science achievement and alterable student, teacher, and school variables. Hypotheses stated in Chapter 1 were tested by *t*-tests and correlation analysis.

This Chapter is divided into the following sections: (1) The Population; (2) The Sample; (3) The Design Effect; (4) Instrumentation; (5) Data Collection; (6) Data Analysis; (7) Reporting of Analyses; and (8) Summary.

The Population

The IEA SISS population universe, Population 3, consisted of all public and private precollege secondary school students in the final year of secondary school. This universe was expanded for the United States assessment to include students who were studying first-year and second-year biology, chemistry, and physics regardless of grade level.

The students in Population 3 were subdivided into three groups:

1. 3B: all students studying biology;
2. 3C: all students studying chemistry;
3. 3P: all students studying physics;
4. 3N: all students not studying science in the last year of precollege secondary school.

In the United States assessment, these subpopulations have been divided into those groups of students studying a first-year course in biology, chemistry, or physics, and those groups of students studying a second-year or advanced course in biology, chemistry, or physics. In the other selected participating countries, subpopulations 3B, 3C, and 3P consisted of students studying the respective science in the last year of precollege secondary school.

Students in other countries who study science throughout their secondary school years generally have been considered to be science specialists in that they have focused their studies in one or more branches of science. Having the U.S. Advanced Science students take the SISS science subject tests permitted greater comparability between U.S. science students and the science specialist students in other countries than would be the case if U.S. students simply studying a given science in the last year of precollege secondary school were tested. It would have been possible for some U.S. students in Grade 12 to be studying a first-year science course rather than a second-year or advanced course. Also, given that many second-year or advanced science courses in the U.S. have prerequisites of successful completion of first-year science courses in the same subject and/or in another science area, it was most likely that the U.S. Advanced Science students would have studied more of the three branches of science than would U.S. students taking an introductory level science course in the last year of secondary school. Thus, the U.S. Advanced Science students were considered to be the best group for comparison with science specialist students in other countries with respect to science preparation.

In the present study, the achievement and associated factors of U.S. Advanced Science students studying biology, chemistry, or physics have been analyzed. The purpose of these analyses was to identify patterns among the factors associated with achievement across science disciplines.

The Sample

The United States conducted the SISS in two phases: Phase I in the Spring of 1983, and Phase II in the Spring of 1986. The following discussion has been limited to Phase II since the present study was part of that phase only.

For Phase II, Research Triangle Institute (RTI), Research Triangle Park, NC, was contracted for the sampling procedures. RTI implemented a three-stage probability sampling design: Stage 1, Primary Sampling Units, (PSUs), consisted of counties or groups of counties; Stage 2, Secondary Sampling Units, (SSUs), consisted of schools within sampled counties; and Stage 3, Tertiary Sampling Units, (TSUs), consisted of intact classes within sampled schools.

PSUs were selected with probability strictly proportional to an estimated composite enrollment size measure. SSUs were selected with probability strictly proportional to an estimated grade-specific school enrollment. TSUs were selected with an equal probability within sampled schools. The eligible student universe was all students in 50 states in public and private schools that included the specific grades.

Selection of Primary Sampling Units

The universe of Primary Sampling Units (PSUs) was constructed by RTI using school level data prepared by Quality Education Data, Incorporated (QED). The QED data tape contains information on both public and private schools and is updated annually with regard to grade-range changes, new school openings, and school enrollment.

For each county, RTI identified schools containing the desired grades and developed grade-specific enrollment counts from the QED school enrollment data and grades contained in the schools. RTI classified each county with three or more schools containing a 12th grade as an individual PSU. Counties with two or less than two schools containing a 12th grade were combined with other such counties within the same state to form a composite PSU.

The sample of 70 PSU selections was drawn with probability strictly proportional to an enrollment-based size measure, where "size" is the number of students in the schools of a county at one of the target grade levels. A sequential probability proportional to size (pps) selection scheme akin to pps systematic sampling was used to achieve implicit stratification on three variables: geographic location, metropolitan status, and total enrollment. To guarantee geographic spread of the PSU sample, all PSUs were classified according to the four Census geographic regions: Northeast, South, Midwest, and West. Metropolitan status was also ascribed to all PSUs by region, and then within region. Finally, within the region-by-metro cells, PSUs were sorted by total enrollment. RTI used a sequential proportional-to-size (pps) selection scheme developed at RTI. This method shares with pps systematic selection the property that each implicit zone of PSUs marked off in terms of 70 equal enrollment size aggregates down the ordered frame listing is guaranteed one and only one selection. The degree of implicit stratification achieved by this sequential zone formation can be improved by switching the direction of metropolitan versus non-metropolitan ordering when moving from one region to the next. This serpentine mode of sorting guarantees that the zones or intervals which overlap regional transition points will consist of PSUs with the same metropolitan status. Similarly, switching the size ordering of PSUs at the seventy region-by-metropolitan status boundaries causes overlapping intervals to include either the largest or the smallest PSUs from the two adjacent region-by-metropolitan cells. The 70 selections resulted in 69 unique PSUs (Los Angeles County was selected twice) including four composite PSUs.

Advanced Science School Screening Sample

For the advanced science school screening sample, RTI made fifteen selections of schools containing a twelfth grade in each PSU (thirty selections in Los Angeles County) with probability proportional to the estimated grade 12 school enrollment. In many PSUs fewer than fifteen unique schools were selected either because fewer than fifteen schools contained a twelfth grade or because major portions of the twelfth grade enrollment were contained in a few schools. The 1,050 selections (15 selections in each of 68 PSUs and 30 selections in Los Angeles County) resulted in 738 unique schools (Table 3).

Table 3

Summary of Sampling for SISS-U.S. Advanced Science Population

Sampling Unit	N
Number of Primary Sampling Units selected	70
Number of Secondary Sampling Units (SSUs) selected	738
Number of SSUs reporting one or more advanced science offerings	444
Number of SSUs reporting advanced biology courses	397
Number of SSUs reporting advanced chemistry courses	245
Number of SSUs reporting advanced physics courses	105
Number of SSUs reporting no advanced science offerings	205
Number of Tertiary Sampling Units (TSUs) selected	135
Number of TSUs in advanced biology sampling frame	47
Number of TSUs in advanced chemistry sampling frame	47
Number of TSUs in advanced physics sampling frame	46

Of the 738 unique schools selected, 444 schools (60.2%) reported one or more advanced science courses and were willing to participate in the study, 205 schools (27.8%) reported no advanced science courses, and 89 schools (12.1%) refused to participate (Table 3). Of the 444 schools willing to participate, 397 schools (89.4%) reported advanced biology courses, 245 schools

(55.2%) reported advanced chemistry courses, and 105 schools (23.6%) reported advanced physics courses. Some schools reported more than one type of advanced biology course (for example, marine biology and anatomy) and some reported more than one section for a given course. A listing of the SISS-U.S. Advanced Science course offerings is given in Appendix A, page 153.

Schools and Class Selection

For the advanced science sample, RTI selected an initial screening sample of schools containing a twelfth grade and requested information on the advanced biology, chemistry, and physics courses for each school. Based on this information, RTI constructed three course-specific school sampling frames and selected 47 schools for the advanced biology assessment, 47 schools for the advanced chemistry assessment, and 46 schools for the advanced physics assessment. These schools were randomly selected with probability proportional to a weighted count of course selections with the limitation that a school would be selected only once for a specified advanced science course. That is, a particular school would have been selected only once for, say, advanced biology, but might have been selected for both advanced biology and advanced chemistry. One section or class with equal probability from each school was then randomly selected for the respective advanced science assessment.

Advanced Science Sampling Weight Calculation

Because of the initial school screening sample for those schools which offered a second-year or advanced science course, a different protocol was followed for computing the sampling weights of the advanced science students, teachers, and school administrators (Duffer and Potter, 1986). The selection probability for each school drawn into the screening sample, P_S(school), was the product of the unconditional PSU selection probability, P(PSU), and the conditional probability of selecting the school given that the PSU was selected, P(school|PSU). That is, P_S(school) = P(PSU)*P(school|PSU). Among schools selected for the screening sample, a school was selected for an advanced science assessment with probability proportional to the weighted number of classes for the particular science (type-h class), that is, for biology, chemistry, or physics. The conditional probability of selection for a school,

$P_h(\text{school}|\text{screened})$, was a function of the unconditional school weight, $WT_s(\text{school}) = 1/P_s(\text{school})$, the number of type-h science classes, $N_h(\text{class}|\text{school})$, and the associated total sample count of science classes, n_h. This selection probability was computed as: $P_h(\text{school}|\text{screened}) = n_h{*}N_h(\text{class}|\text{school}){*}WT_s(\text{school})/N_h$ with N_h representing the weighted total count of type-h classes; namely, $N_h = E\,[N_h(\text{class}|\text{school}){*}WT_s(\text{school})]$. The unconditional school probability, $P_h(\text{school})$, for the type-h advanced science assessment was the product of the unconditional probability of selecting the school for the screening sample, $P_s(\text{school})$, and the probability of selecting the school for the assessment given that it was screened, $P_h(\text{school}|\text{screened})$. That is, for type-h advanced science, $P_h = P_s(\text{school}){*}P_h(\text{school}|\text{screened})$. Because only one class was selected in each school for each type of science, the conditional probability of class selection within a sampled school was the inverse of the number of classes, $1/N_h(\text{class}|\text{school})$. The unconditional probability of a class type-h selection, P(class), was computed as: $P_h(\text{class}) = P_h(\text{school})/N_h(\text{class}|\text{school})$. That is, the sampling procedures allowed for each advanced science class of a given type to have the same probability of selection and, hence, the same sampling weight. To minimize the burden on individual schools, a restriction was imposed on the sample design that limited each school to only one class selection for each type of advanced science course. This restriction was implemented during sampling activities by assigning $P_h(\text{school}|\text{screened})$ equal to 1.0 whenever $P_h(\text{school}|\text{screened})$ was greater that 1.0 and distributing excess allocation among the other schools. In practice, only a few schools were affected by this restriction and most advanced science classes were selected with equal probability.

Because intact classes were used for the advanced science assessment, the student selection probability and the teacher selection probability equaled the class selection probability and the respective sampling weights were the inverse of the unconditional advanced science class selection probability, $P_h(\text{class})$. The school administrator sampling weight equaled the inverse of the unconditional advanced science school selection probability, $P_h(\text{school})$.

Having used a two-phase design to select the schools for the advanced science assessment, RTI compensated separately for school noncooperation at the screening phase and for nonresponse after a school was selected for the assessment. Of the 738 schools selected by RTI for screening for advanced science courses, 649 schools provided information and were willing to cooperate and 89 schools declined participation. Of the 649 cooperating schools, 444 schools offered an advanced science course, and 205 schools reported no advanced science offerings. The schools which reported no advanced science offerings were classified as ineligible and were not included in the nonresponse adjustment. RTI computed the school response adjusted weight as the product of the unconditional school screening weight and the inverse of the weighted school response rate. The weighted school response rate was computed as the sum of the unconditional school weights for the 444 cooperating schools offering advanced science divided by the sum of the unconditional school weights for the 444 schools plus the 89 noncooperating schools. The final student weight was computed by compensating for the screening nonresponse adjusted class weight for school and student nonresponse.

The advanced science assessment consisted of two administrations: Booklet 1 and Booklet 2. A student was classified as a respondent if three or more items were attempted for a given administration. Because a student could be classified as a respondent for either administration or for both administrations, RTI computed three adjusted student weights. The fully adjusted student analysis weights (adjusted for school screening nonresponse, for school noncooperation, and for student nonresponse) were computed as the product of the screening nonresponse adjusted class weight, the inverse of the unweighted school cooperation rate, and the inverse of the unweighted student response rate.

For Advanced Science teachers and school administrators, RTI computed a single nonresponse adjusted weight for each. For teachers, the final teacher analysis weight (adjusted for school screening nonresponse, for school noncooperation, and for teacher nonresponse) was computed as the product of the screening nonresponse adjusted class weight, the inverse of the unweighted school cooperation rate, and the inverse of the unweighted teacher response rate. Similarly, for school administrators, the final school administrator analysis weight (adjusted for school screening nonresponse, for school noncooperation, and for school administrator nonresponse) was computed as the product of the unweighted school screening nonresponse rate, the inverse of the unweighted school cooperation rate, and the inverse of the unweighted school administrator response rate.

Sampling Weight Trimming

Although the survey was designed to minimize variation in the student analysis weights, because of inexact counts of students in all schools and because of variation in response rates, the response adjusted weights for some students were substantially larger than those for other students. Such variation in the student analysis weights would have decreased the precision of sample estimates relative to the precision obtained from an equal probability sample of students. A standard estimation procedure designed to improve precision when substantial variation exists among analysis weights is to trim excessively large weights and to distribute the excess across the weights for the untrimmed remainder of the sample. However, this trimming procedure introduces some bias in the estimates. By minimizing the number of weights trimmed to only the most extreme values, the biasing effects of trimming can be minimized and the overall precision increased. For the student weights, RTI trimmed less than 2% of the weights, and for teachers and school administrators, RTI trimmed the weights for at most three teachers from any sample.

SISS Response Experience

For the advanced science assessment, SISS teacher/school administrator response rates were generally between 80 and 90% and all student response rates were in excess of 80% of the target student populations.

RTI selected 47 classes for advanced biology, 47 classes for advanced chemistry, and 46 classes for advanced physics. Of these, 43 classes participated in advanced biology, 41 classes participated in advanced chemistry, and 34 classes participated in advanced physics. In general, each class was in a unique school. Some schools were selected for more than one advanced science assessment. In such cases, more than one advanced class participated in a school; however, the classes were assessed in different advanced science subjects. A summary of student response rates is given in Table 4. Teacher, and school administrator response rates are presented in Table 5.

Table 4

Summary of SISS - U.S. Advanced Science Student Response Rates

Course	Classes in Eligible Schools	Participating Schools		Total Students	Responses to Administrations*					
					First		Second		First & Second	
		N	%		N	%	N	%	N	%
Biology	47	43	91.5	785	674	85.9	645	82.2	630	80.3
Chemistry	45	41	91.1	656	562	85.7	559	85.2	540	82.3
Physics	40	34	85.0	580	500	86.2	488	84.1	474	81.7
TOTAL	132	118	89.4	2021	1736	85.9	1692	83.7	1644	81.4

*The first administration was Booklet 1: the science achievement test. The second administration was Booklet 2: the Mathematics and Word Knowledge Tests, and Student Questionnaire.

Table 5

Summary of SISS-U.S. Advanced Science Teacher and School Administrator Response Rates

Classes in Eligible Subgroup	Schools	Participating Teachers		Classes Associated With Participating School Administrators*	
		N	%	N	%
Biology	47	43	91.5	41	87.2
Chemistry	45	41	91.1	37	82.2
Physics	40	34	85.0	34	85.0
TOTAL	132	118	89.4	112	84.8

*Because more than one class may be selected in a given school (one class per science subject), the number of responding school administrators is less than the number of classes associated with a responding administrator.

School Response and Replacement Schools

The cooperation rate for the advanced science classes was at, or in excess of 82.2%. Just prior to or during data collection, RTI identified six advanced science courses incorrectly classified as physics (Tables 4 and 5 reflect the classification after the error was corrected). Noncooperation for the advanced science classes was 11%.

The replacement strategy to identify a replacement school for any noncooperating or ineligible school was to select a replacement unit from the same implicit stratum as the initial sample unit. Replacements were selected only after extensive efforts had been made to convert refusals. For the PSUs where implicit stratification was a function of geographic region, metropolitan status, and total enrollment, a noncooperating PSU was replaced by the next listed unit on the ordered primary frame. Such a strategy maximized the likelihood that the replacement PSU was from the same region, had the same metropolitan status, and was similar in size. For a noncooperating county cluster within a composite PSU, the next unit in the ordered frame of county clusters was designated as the replacement county cluster.

Nonparticipating schools were replaced using a predetermined substitution rule similar to that specified for primary units. The two school selections per grade, or per advanced science course offered, were drawn from a schools listing sorted by an affiliation variable with three levels: public, Catholic, and other private, and by estimated grade enrollment. Following the original frame ordering, the next listed school in the ordered frame was designated as the replacement. This procedure maximized the likelihood of affiliation and size matching. For replacement PSUs and schools, the sampling weight was the inverse of the selection probability of the replacement unit.

Since some schools delayed the decision not to cooperate until data collection was about to start, RTI could not designate a replacement for all noncooperating schools. Because of such delays and because ineligible advanced science courses could not be identified until data collection started, RTI designated and fielded only one advanced science replacement class. No replacement PSUs were selected for the advanced science assessments.

Adequacy of the Sample

Wolf (1986) reported on the nature of the 1983 U.S. samples with respect to the adequacy of the samples. Evidence on the precision of estimators of standard errors obtained from the data was determined through a series of jackknifing studies which showed that the standard errors were acceptably low and in accordance with estimates obtained in the First International Science Study.

The evidence for representativeness of the samples was derived from two sources: marker variables, and the results from a questionnaire completed by a number of schools that had declined to participate in the 1983 sample. These data were compared with data on the same variables for schools that did participate. No marked discrepancies or differences were noted by Wolf.

A key "marker" variable in survey research is the distribution of gender within a sample. As can be seen from the data in Table 6, the percentages of males and females in the SISS Advanced Science sample compare very closely with the samples obtained in the High School and Beyond (HS&B) study carried out in 1984. The HS&B data represent the percent of seniors who took advanced science courses by sex.

Table 6

SISS and HIGH SCHOOL AND BEYOND: Comparison of Distribution of Students by Sex Within Subgroup

Subgroup	Sex	Distribution of Students by Sex			
		SISS (1986)*		HS&B (1984)**	
		N	%	N	%
Advanced Biology	Female	374	57.8	691	54.4
	Male	272	42.1	578	45.6
Advanced Chemistry	Female	232	43.0	126	41.0
	Male	307	57.0	183	59.0
Advanced Physics	Female	106	22.0	32	25.8
	Male	381	78.0	92	74.2

*Numbers of students not responding to item on student sex by advanced science subgroup: Biology, 28; Chemistry, 23; Physics, 12.

**Source: High School and Beyond, 1984.

Based on Wolf (1986), analyses of FISS sampling procedures and results, experiences of RTI staff with similar studies, and the financial and time constraints of SISS, RTI determined that a designed sample of 140 schools was adequate for the U.S. Advanced Science population.[4]

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[4] The explanation of the determination of the design sample for the U.S. Advanced Science population was based on a discusion with Richard M. Wolf, Chair, Department of Measurement, Evaluation, and Statistics, Teachers College,

The Design Effect

The degree of accuracy associated with a sample estimate is dependent upon the sampling procedure used. For probability samples such as the SISS samples, the variance of a particular probability sample estimate is compared with that for an equivalent simple random sample (srs) (Kish, 1965, p. 162). Kish (1965, p. 162) introduced the term "deff" (design effect) to describe the ratio of the variance of the sample mean for a complex sample design, denoted *c*, to the variance of a simple random sample, denoted *srs*, of the same size:

$$\text{deff} = \frac{\text{var}(x_c)}{\text{var}(x_{srs})}$$

An alternative formula is

$$\text{deff} = 1 + \text{roh}\,(b-1)$$

where roh (the rate of homogeneity) is equal to the intraclass correlation coefficient (rho) and b is the average number of students per cluster. Roh provides a measure of the degree of homogeneity within clusters. In educational settings, the concept of homogeneity within clusters may be observed in the tendency of student characteristics to be more homogeneous within schools or classes than if students were assigned to schools or classes at random. This homogeneity may be due to common selective factors (for example, residential zoning of schools), to joint exposure to the same external influences (for example, teachers and school programs), to mutual interaction (for example, peer group pressure), or to some combination of these factors.

The "effective sample size" is equal to the size of a simple random sample which has a level of sampling accuracy, as measured by the variance of the sample mean, which is equal to the sampling accuracy of the given complex probability sample. The actual complex probability sample size, denoted nc, and the effective sample size, denoted n^*, are related to the design effect (deff) associated with the complex sample (Ross, 1978, pp. 137-138):

$$nc = n^* \times \text{deff}$$

Columbia University. Dr. Wolf had been involved with the SISS-U.S.A. for both Phase I and Phase II, and serves as U.S. A. delegate to the IEA.

Deff may be replaced in the above formula by an expression which is a function of cluster size and the coefficient of intraclass correlation:

$$nc = n^* \; [\, 1 + (b - 1)\, roh]$$

Ross (1987) has indicated that for a given population of students, the value of roh tends to be higher for clusters based on classes rather than clusters based on schools. Thus, for studies involving intact classes within schools, such as the SISS-U.S.A. samples, large values of roh would be expected. These large values of roh would affect the effective sample size and, in turn, the sizes of the absolute values of the t values, F ratios, correlation coefficients, and regression coefficients which would be considered as statistically significant at the 0.05 level.

For the present study, effective sample sizes were determined for each of the subpopulations of U.S. Advanced Science students using values of roh reported in *Science Achievement in Seventeen Countries - A Preliminary Report* (IEA, 1988), pages 51-53. Table 7 summarizes the effective sample sizes of the three subpopulations for Biology, Chemistry, and Physics.

Table 7

Effective Sample Sizes for SISS-U.S. Advanced Science Subgroups

Subgroup	Achieved Sample Size	b	roh	deff	Effective Sample Size
Biology	674	18.030	0.40	7.812	86
Chemistry	562	21.378	0.49	10.985	51
Physics	500	16.896	0.38	7.041	71

The relatively high values of roh reflect the heterogeneity of the public schools in the United States due to local autonomy of school boards of education, individual school administrations and teachers, and communities with regard to curriculum development and implementation and the selection processes for enrollment in differentiated courses such as advanced level science courses. The effect of roh on effective sample size is quite apparent from the data given in Table 7. The disparity between the actual sample sizes for students and the calculated effective sizes is strong evidence that caution be used in making inferences and drawing conclusions from the sample data for generalizations about the SISS-U.S. advanced science student/teacher/ school populations.

Sample design tables can be prepared to present a range of sample design options--each designed to have a pre-specified level of sampling accuracy. For example, assume that SISS-U.S.A. had as one of its aims the estimation of the percentages of the students in the three advanced science populations that are able to obtain correct answers. In addition, assume that a sampling accuracy constraint had been placed on the design of the study to insure that the sample estimate of the percentage of students providing the correct answers, p, will provide p ±5% as 95% confidence limits for the value of the percentage in the population.

For reasonably large samples, it is possible to assume normal distribution of the sample estimates (Kish, 1965, p. 13-14) and therefore confidence limits of ±5% are approximately equivalent to an error range of plus or minus two standard errors of p. Thus, the error constraint placed on the study means that one standard error of p needs to be less than or equal to 2.5%. By using the following formula (Kish, 1965, p. 46)

$$\mathrm{var}(p) = p\ (100 - p)\ / n^* - 1$$

where n^* is a simple random sample of students selected from the population in order to calculate values of p, the maximum value of p(100-p) occurs for p = 50. Therefore, in order to insure that the error constraints described above (p less than or equal to 2.5%) would be satisfied, the following inequality would need to be valid:

$$(2.5)\ 2 \geq 50\ (100 - 50)\ / n^* - 1$$

Solving the inequality results in a value for n* greater than or equal to 400 students in order to obtain 95% confidence limits of p ±5%.

To determine the size of the complex probability sample of teachers/ schools which would give an effective sample size of 400 for each of the SISS-U.S.A. Advanced Science subpopulations, the formula

$$a = (400 / b) \times [\ 1 + (b-1)\ \mathrm{roh}]$$

where a is the number of primary sampling units (in this case, the number of schools) and b is the number of secondary sampling units to be selected from each primary sampling unit (in this case, students) would be used.

Consider the actual SISS-U.S.A. data wherein b is equal to the actual average number of students per class for each subpopulation and the values for roh are 0.40 for biology, 0.49 for chemistry, and 0.38 for physics. Table 8 presents a summary of calculations to determine the sizes of the complex probability samples for the student populations and for the teacher/school populations based on an effective sample size of 400 students.

Table 8

Calculated Sizes of Complex Probability Samples for SISS-U.S.A. Advanced Science Subgroups Based on Effective Sample Size of 400

Advanced Science Subgroup	Actual Student Sample Size	Actual Teacher/School Sample Size	roh	b	deff	Calculated nc	 a
Biology	674	43	0.40	18.030	7.812	3119	173
Chemistry	562	40	0.49	21.378	10.985	4404	206
Physics	500	34	0.38	16.896	7.041	2822	167

As shown in the above table, the calculated student and teacher/school sample sizes are much larger than those in the SISS-U.S.A. study design with regard to eligible classes and schools (see Tables 4 and 5, page 49). Comparisons of the sizes of the actual student and teacher/school samples with those of the calculated samples for both the number of primary sampling units, a, (in this case, schools) and the secondary sampling units, *nc*, (in this case, students) provide additional evidence that caution be used in making inferences and in drawing conclusions from the results of the sample analyses for the SISS-U.S.A. Advanced Science populations, especially in making generalizations about the U.S. advanced science student and teacher/school populations.

The significance of *t*-tests regarding the difference between two means obtained for independent samples is affected by the design effect. Use of the *t*-test assumes a simple random sample (*srs*). However, with a complex sampling design such as that employed in the SISS, a deff factor should be used to account for the degree of clustering associated with the use of intact classes. The value of the standard error of the difference in sample means, *sd*, in the estimate of the *t* ratio would be

$$sd = s \sqrt{[\,2(deff)/n\,]}$$

where n is the sample sizes of the two groups (x_1, x_2) in the comparison. The corresponding estimate of *t* ratio would be

$$t_{cluster} = (x_1 - x_2) / \{ s \sqrt{[\,2(deff)/n\,]} \}.$$

The omission of the deff factor in the estimation of the *t* statistic leads to the possibility that the differences in mean scores between the comparison groups could be mistakenly interpreted as being statistically significant, when in fact the differences are within the range of values attributable to chance.

A similar situation concerns the value of the F ratio since the value of the F ratio is equal to the square of the *t* ratio when only two groups are used. In such a case, the adjustment factor for the F ratio would be equal to deff.

Ross (1978) determined that, for many complex sample designs commonly used in evaluation research, the values of deff for sample means and multivariate statistics such as correlation coefficients and regression coefficients are greater than one. Thus, the accuracy of sample estimates in such studies may be grossly overestimated if the formulae used to calculate sampling errors are based on simple random sampling assumptions.

As Kish (1965) has indicated, the computational formulae required to estimate the variance of descriptive statistics such as sample means, are available for a wide range of probability sample designs which incorporate complexities such as stratification and cluster sampling. However, formulae for multivariate statistics such as correlation coefficients and regression coefficients are not readily available and are either enormously complicated or prove resistant to mathematical analysis (Frankel, 1971).

Using jackknifing, one of the techniques for determining adjusted sample estimates of complex sample designs, Peaker (1975) established protocols to be followed and parameters to be used in subsequent analyses of IEA studies. For SISS, the standard errors of sampling of national means were calculated using the jackknifing technique based on the deletion of one primary unit (the school) at a time (IEA, 1988, p. 22). It has been recommended that readers of the SISS reports refer to the standard errors when examining possible differences in means between countries (IEA, 1988, p. 22).

Based on the FISS analyses, Peaker (1975, pp. 126-140) suggested values of p to be used in IEA studies when determining deff factors for the following statistics:

$p = 0.2$ in estimating standard error of means;
$p = 0.06$ in estimating correlation coefficients; and
$p = 0.04$ for estimating regression coefficients.

Following Peaker's protocol, deff factors were calculated for each of the U.S. Advanced Science populations and are presented in Table 9.

Table 9

Deff Factors for Estimating Standard Error of Sample Means, Correlation Coefficients, and Regression Coefficients

	Deff Factors for Estimating:		
Advanced Science Population	Standard Error of Sample Means	Correlation Coefficient	Regression Coefficient
Biology	4.406	2.022	1.681
Chemistry	5.076	2.223	1.815
Physics	4.179	1.954	1.636

This researcher did not have the facilities to utilize a computer program which could take into account the deff factors for the estimations of the *t* values, F ratios, correlations coefficients, or regression coefficients. All univariate and multivariate analyses were performed using the standard procedures for the above analyses available with SPSS^{X} which assume a simple random sampling design. The deff factors for each of the statistics in question have been calculated by the researcher (Table 9) and should be kept in mind by the reader when independently making inferences and drawing conclusions from the reported data.

Instrumentation

The survey instruments consisted of four booklets for each science subject to be assessed, two student booklets, one teacher booklet, and one school administrator booklet. The first student booklet contained science subject test items. The second student booklet contained a Mathematics Test appropriate for the science subject and level, a Word Knowledge Test appropriate for the level, a Student Questionnaire, a Student Opinionnaire, and a Student Science Learning Inventory. Booklet 2, containing the Mathematics Test, Word Knowledge Test, Student Questionnaire, Opinionnaire, and Description of Science Learning, is presented in Appendix B, page 154.

Two categories of items and instruments were developed, namely, international core components to be done by all participating countries and international option components to be included at the discretion of the individual countries. Each educational system had the responsibility for incorporating the international core instruments into its national testing program.

The original language of all instruments was English. In those countries where English was not the language of instruction, the instruments were translated into the appropriate language. Where resources were available, the instruments were back-translated into English and the results compared with the official English version.

Two conditions had to be met during the development of the specific science subject test items. First, the items had to reflect a "consensus" science curriculum based on analyses of science curriculum ratings supplied by the participating countries. Thus, no one country's curriculum "drove" any science test. Second, there had to be a sufficient number of items to give a reasonable sampling of the consensus curriculum. Time constraints with regard to length of time that could be requested from a school system for administering the SISS instruments and have the least amount of time taken from the instructional learning time were also a factor in determining the lengths of the SISS instruments. Therefore, given the consensus curriculum and the limited number of questions used, the SISS science subject tests may be regarded as being "equally unfair" to all countries. The United States was not as deeply involved in the development of the biology and chemistry tests as it had been in the development of the physics test. However, the items in the biology and chemistry tests were determined to be representative of the topics taught in advanced biology and advanced chemistry by the SISS-U.S.A. committee involved with test development. The Achievement Tests are presented in Appendix E, pages 195-226.

Teachers of classes which were tested were asked to give an opportunity-to-learn (OTL) rating for each of the items on the test for their specific course/class. OTL ratings have been summarized in Appendix F, page 245.

Tables 10, 11, and 12 provide summaries of the specific science tests with the science content areas covered, the numbers of the test items which dealt with each area, and the percentage of the total test for each area.

Table 10

Summary of SISS-U.S. Advanced Biology Test Items by Content Area

Content Area	Test Item Numbers*	Percent of Total Test (Total n = 30)
Cell Structure/Function	S01, S04, S10	10.0
Plants: Structure/Function	S05, S13, S17	10.0
Animals: Structure/Function	S03, S11, S14, S15, S16, S18, S21, S24*, S30*	30.0
Evolution	S23, S27, S28, S29	13.3
Genetics	S02, S06, S07, S08, S09	16.7
Data Interpretation	S12, S19, S20, S22*, S25*, S26*	20.0

* Denotes U.S. national option items.

Table 11

Summary of SISS-U.S. Advanced Chemistry Test Items by Content Area

Content Area	Test Item Numbers*	Percent of Total Test (Total n = 30)
Theoretical Chemistry	S10*, S2	6.7
Energy	S04, S21, S22, S23	13.3
Solutions	S01, S02, S18, S28	13.3
Acids and Bases	S06*, S09*, S11, S17, S19	16.7
Reactions	S03*, S08, S13, S14, S15, S24, S25, S26*, S27	30.0
Oxidation-reduction	S05, S07 S12, S16	13.3
Organic Chemistry	S10, S16, S27	10.0
Nuclear Chemistry	S29, S30	6.7

* Denotes U.S. national option items.

** Total exceeds 100% because questions S10 and S27 fit into more than one content area and therefore have been counted more than once.

Table 12

Summary of SISS-U.S. Advanced Physics Test Items by Content Area

Content Area	Test Item Numbers*	Percent of Total Test (Total n = 30)
Mechanics	S01 to S12	40.0
Heat	S13 to S16	13.3
Optics	S17 to S22	20.0
Electromagnetism	S23 to S25, S26*, S27*	16.7
Modern Physics	S28*, S29*,S30	10.0

* Denotes U.S. national option items.

The Mathematics Test was a multiple-choice test and contained 20 items that tested basic concepts and skills appropriate for each population. A mathematics test had not been used in FISS.

The Word Knowledge Test was a test of verbal ability that contained 40 dichotomous response items (response choices were "same" or "opposite") that were appropriate for each population and which had been used in FISS.

The Student Opinionnaire consisted of a set of 28 international attitude scales designed to measure the various attitudes of the quality of school life, importance of science, enjoyment and facility of science, and career interest in science. The Description of Science Learning was a set of 24 international and U.S. national option items designed for students to describe activities which took place in the science classroom.

The Student Questionnaire included 15 international and U.S. national option items which sought basic information from students: sex, age, grade level, science course history, educational and occupational aspirations, parental education and occupations, number of books in the home, number of years of mathematics studied since eighth grade, time spent in class on science, time spent watching television, access to and time spent with computers at school, and time spent on homework.

The Teacher Questionnaire was designed for use by all teachers who taught science to the students in the test population sample. There were 44 international and U.S. national option items in the Teacher Questionnaire. Requested information included sex, age, education, teaching experience, certification, membership in professional organizations, use of computers in the science class, hours spent in preparation for class at home and in school, hours spent teaching science and math, attitudes toward science, importance of what the students will need with regard to the science curriculum, and methods of evaluating student performance in science. The Teacher Questionnaire is presented in Appendix C, page 175.

The School Questionnaire was designed for completion by the school principal or teacher in charge of science. There were 15 international and U.S. national option items which requested information on school location, area population, school student population, student enrollment in science, instructional time allocation, sources of funding for the school, distribution of total faculty by sex, distribution of science faculty by sex, and allocation of rooms dedicated for science. The School Questionnaire is presented in Appendix D, page 186.

Data Collection

Data for the United States participation in the SISS Advanced Science Student assessment were assembled during 1986 by Research Triangle Institute. The data were processed at Teachers College, Columbia University under the direction of Dr. Willard J. Jacobson, U.S. National Research Coordinator-SISS, and Dr. Rodney L. Doran, Associate U.S. National Research Coordinator-SISS.

Data Analysis

The Statistical Package for the Social Sciences-version X ($SPSS^X$) was used on the DEC-20 computer at Teachers College, Columbia University to perform all analyses of data.

Descriptive statistics were obtained for all variables for each of the U.S. Advanced Science subgroups and included frequency distribution, mean, standard deviation.

T-tests were used to test the equality of the mean science scores of groups of students with respect to specific teacher variables including teacher science education, reading of academic journals, reading of science journals, participation in inservice programs, membership in science teacher or science association.

This researcher chose to use multiple regression analysis rather than ANOVA in summarizing the data for two reasons. Multiple regression analysis is more comprehensive and allows a general approach on the conceptual as well as the analytic level. The use of ANOVA implies a factorial design with categorical independent variables whereas multiple regression analysis can deal with both categorical and continuous independent variables which are viewed from the same frame of reference: information available when attempting to explain or predict a dependent variable (Pedhazur, 1982, p. 328).

Since the additional subdivisions within each subject area further decreased the sample sizes, this author chose not to perform multiple regression analyses within each subdivision, i.e, for Advanced Placement and non-Advanced Placement, or for grade levels within each subdivision. Regression analyses were used for each single subject area, i.e., biology, chemistry, and physics, in order to have the largest possible sample sizes.

The student achievement test scores were analyzed on the basis of those items which were common to the achievement tests administered by other participating countries as well as on the basis of all 30 items as presented in the U.S. tests. There were 25 common items in the biology test, 25 common items in the chemistry test, and 26 common items in the physics test.

Recoding of Variables

In order to obtain meaningful information from the data, variables in the student, teacher, and administrator questionnaires were recoded so as to be monotonic. Recoding was also necessary for the attitude items in both the student and teacher questionnaires so that a high value on an item would be interpreted as positive in attitude while a low value on an attitude item would be interpreted as negative in attitude. Some of the attitude items were stated in a negative context so that a response of "Disagree" would actually reflect a positive attitude. Recoding of such items gave the "Agree" choice the lowest value and the "Disagree" choice received the highest value. Some items had response choices of "Frequently," "Occasionally," "Rarely," and "Never." For most of the items, the highest value was assigned to "Frequently" and the lowest value to "Never." Item recodes for all questionnaires are given in Appendix G, page 246.

Missing Data

Missing data through nonresponse included unit nonresponse or total lack of information from a unit in the sample, e.g., a student in a school or a whole school (missing cases), and item nonresponse or lack of information from a unit in the sample for specific aspects of the survey (missing values).

Three situations which may have resulted in unit nonresponse were: a particular student was absent on the data collection days and so takes no part in the survey; the data from a particular student were lost following the completion of the survey; a school declined to participate in the survey.

Item nonresponse, on the other hand, may have occurred when the student was present and took part in the survey but, for some reason, did not supply all the information requested. For example, a student may have omitted one or more items in an instrument. Such an omission may have been intentional or unintentional.

Intentional omissions might have arisen because the student: a) did not wish to supply the information; b) did not know the information requested; c) was unable to solve the problem required to give the information; d) did not understand the question. Sometimes the data were supplied by someone other than the student, e.g., a teacher or school administrator. In this case, the data loss occurred because the teacher or administrator did not know the answer, was unwilling to supply the answer, or unintentionally omitted the answer.

Item nonresponse may have been random or non-random. Non-random missing data would occur if some influence were working systematically in the sample. For example, parents of a particular ethnic background may have refused to supply information about their education to the students.

Two strategies commonly used to handle missing data are deletion and compensation. Deletion may involve: a) the deletion of a variable if a substantial proportion of cases have missing data codes; b) the deletion of particular cases which omitted data on a given variable; and c) the partial deletion of cases when two or more variables are used in analysis (only those cases which had valid values for all variables in analysis were used).

Compensation involves filling in the gaps left by the missing data with plausible values. Certain assumptions are made regarding the use of compensation: a) respondents and nonrespondents have the same mean for the variable on which data are missing; and b) missing data are random. The assumption of equal means does not imply equal distribution around the mean. However, the assumption of random missing data does imply equal variance between respondents and nonrespondents.

According to IEA/SISS Memorandum 122 (1984), page 8, concerning missing data:

1) missing cases: weighting adjustments have been applied as discussed above;
2) missing values in general: variables with more than 20% missing values have not been included in composite variables or used in explanatory analyses;

3) missing values on cognitive items: the calculations of scores for tests have been based on the sum of items with correct responses; items with high percentages of missing values have been reported and discussed;
4) missing values on attitude scales: where there were missing values for more than 20% of the items in a given scale for a given respondent, the respondent was assigned the missing value code for that scale; where there were missing values for less than 20% of the items in a given scale for a given respondent, the respondent was assigned the code for the "neutral" position for that scale (this was done by RTI when the scales were scored);
5) missing values on descriptive variables: where composite variables were constructed, a respondent had valid values for more than 80% of the items in the composite variable, otherwise the respondent was assigned the missing value code for that variable; where the respondent had missing values for less than 80% of the items in the composite variable, a value was assigned based on the sum of the standard scores for the constituent variables for which valid values were available for the respondent.

Composite Variables

Composite variables were developed in order to establish meaningful explanations of variations in criterion scores because a large number of potentially explanatory variables was available.

Individual variables in the data set were often empirically or conceptually related. Intercorrelations between explanatory variables treated individually are sources of instability and fluctuations in multivariate analyses. Combining related variables avoids effects. of multicollinearity. In accordance with IEA/SISS Memorandum 121 (1984) and theoretical considerations, composite variables were developed to obtain groups of variables in order to reduce the total number of variables and to reduce the effects of multicollinearity among variables.

For each SISS-U.S. Advanced Science subgroup, partial correlations were obtained for the student variables (controlling for the effects of teacher and school variables), for the teacher variables (controlling for the effects of student and school variables), and for the school variables (controlling for the effects of student and teacher variables). Variables that were positively and significantly associated with SISS-U.S. Advanced Science student achievement and had a theoretical basis for consideration were included in the variable sets for the multiple regression analyses. Composite variables are presented on page 126.

Reporting of Analyses

Descriptive statistics for the data obtained from the student, teacher, and school questionnaires included mean, standard deviation, total number of respondents for each item (Appendices H, I, and J, pages 248, 264, and 274 respectively). Pearson product-moment coefficients were obtained for all questionnaire variables (Appendix K, page 278). Partial correlation coefficients were obtained for those variables and composites to be considered for the multiple regression analyses (Appendix L, page 282).

The achievement scores student populations in biology, chemistry, and physics were analyzed further on the basis of the course having been designated as Advanced Placement (AP) or not having been so designated (non-AP). AP courses in high school may be taken for college credit and, in order to insure a degree of uniformity across all such courses in a given subject, have a common syllabus by course. Students enrolled in AP courses have been prepared to take the appropriate AP examinations administered by the Educational Testing Service, Princeton, NJ in order to be evaluated for college credit acceptance. Thus, the AP curricula are the closest to "national" curricula in those subjects so designated. Since the non-AP courses did not necessarily share a common curriculum, it was decided by this author that comparisons between the AP and non-AP science students would be of interest to science educators.

Science achievement test scores have been presented by subject area, grade level, and by characteristics of the students with regard to the number of years of science and mathematics studied in grades 9-12, and to the kind of science, i.e., physical or biological, which formed the majority of the science courses studied.

Summary

The Second International Science Study - U.S.A. tested more than 12,000 students in 597 classes with usable data from approximately 84% of the initial sample of more than 14,000 students. The U.S. Advanced Science assessment involved a three-stage probability sample of 1736 public and private school students who were studying a second-year (advanced) course in biology, chemistry, or physics in 118 schools across the United States.

Three structured questionnaires had been developed and sent to the administrators of the schools in which testing was to be conducted, to the teachers of the classes to be tested, and to the students to be tested. The administrator questionnaire requested information concerning the school location, area population, organization of the school day, school enrollment by grade and science course, number of male and female science teachers, number and percentage of use of laboratory facilities, and graduation requirements in mathematics.

The teacher questionnaire requested information about teacher sex, age, education, teaching experience, certification, membership in professional organizations, amount of time spent in preparation for classes at home as well as at school, hours spent teaching math and science, importance of what the students will need with regard to the science curriculum, and teaching methodologies.

The student questionnaire sought basic information about the student's sex, age, grade level, science course history, number of years of mathematics studied since eighth grade, access and use of computers in school, time spent watching television, time spent on homework, educational and occupational aspirations, parental education and occupations, and the number of books in the home. The student questionnaire contained attitude scales which were designed to measure attitudes toward various aspects of the quality of school life, importance of science, enjoyment and facility of science, and career interest in science. A third part of the student questionnaire included a set of items designed for students to describe activities which take place in the science classroom. Students were given a science subject achievement test appropriate for the science course in which they were enrolled. Students were also given a Mathematics Test and a Word Knowledge Test appropriate for the science course level.

Data were gathered and coded by the Research Triangle Institute (RTI), Research Triangle, NC. Data transformations, such as recoding of variable values and the development of composite variables and analyses such as frequency distributions, Pearson and partial correlations, *t*-tests, and multiple regression, were performed using the statistics package SPSS^X on the DEC-20 mainframe computer at Teachers College, Columbia University.

CHAPTER IV

ANALYSIS OF RESULTS

Introduction

The results from the student science achievement tests, and student, teacher, and school administrator questionnaires encompassing more than 200 variables are presented in this chapter. Discussion has been organized in relation to the hypotheses stated in Chapter I, pages 9-10.

For presentation of the discussion of the study, this chapter is divided into the following sections: Background Characteristics of Students; Background Characteristics of Teachers; Background Characteristics of Schools; Tests of Stated Hypotheses; Regression Analyses; and Summary.

Background Characteristics of Students

There were 18 items concerning student and home background to which students were asked to respond. The items included sex of the student, grade level of the student, a science course history (Grades 7-12), student aspiration for further education and types of coursework, amount of television watched per week, amount of homework done for all subjects and for science subjects, access to calculator and computer, use of computer at school, number of years of mathematics studied since eighth grade, parental/guardian level of education and occupation, and number of books in the home.

Sex. The distribution of males and females in the U.S. Advanced Science population subgroups by science discipline is shown in Table 6, page 51. Female students outnumbered males only in the SISS-U.S.A. Advanced Biology subgroup (57.8% female students). In the Advanced Physics subgroup, the percentage of female students was 22% of the total student subgroup.

Grade. The distribution of U.S. Advanced Science students among grades 10-12 is shown in Table 13. The grade level of students should be considered when making comparisons of achievement either within a country or among countries for reasons that include opportunity to have studied science in school as well as the amount and kinds of mathematics studied, and the cognitive development of the student. For example, a student in the 12th grade would have had four academic years in which to study science and mathematics whereas a 10th grade student would have only two academic years in which to study these subjects.

Table 13

Grade Distribution of SISS-U.S. Advanced Science Students (Numbers and Percent* of Students)

	Grade Level						
Subgroup	10		11		12		Total**
	N	(%)	N	(%)	N	(%)	N
Biology	134	(20.1)	173	(25.9)	361	(54.0)	668
Chemistry	1	(0.1)	186	(33.1)	375	(66.7)	562
Physics	2	(0.4)	50	(10.0)	448	(89.7)	500

*Percent may not total 100 due to rounding.
**Six students in Advanced Biology did not indicate grade level.

Science Course History. Table 14 presents the data which give the types of science courses taken and the grade in which each was taken for the three advanced science populations. Since a student may have taken more than one course in a given grade, no attempt has been made to give percentages of students who had taken each course type.

For the Advanced Biology population, of those who responded for each course type and grade taken, the majority had taken either physical science or first-year biology in the 9th grade. Few Advanced Biology students reported having studied a second-year chemistry or a first-year physics course.

Table 14

Types of Science Courses and Grade Taken, Grades 9-12: Number of Students Responding by SISS-U.S. Advanced Science Subgroup*

Advanced Science Subgroup	Science Course Taken	Grade During Which Science Was Taken, Grades 9-12			
		9	10	11	12
BIOLOGY					
	General Science	40	4	5	1
	Earth Science	53	2	1	3
	Life Science	19	2	1	3
	Physical Science	202	9	6	3
	Environmental Science	24	33	6	0
	First-year Biology	251	303	29	3
	First-year Chemistry	1	114	226	17
	First-year Physics	9	9	48	60
	Second-year Biology	4	103	134	243
	Second-year Chemistry	1	3	18	35
	Second-year Physics	0	0	1	7
	Other science course	21	49	62	76
CHEMISTRY					
	General Science	24	3	1	0
	Earth Science	26	3	1	1
	Life Science	17	5	1	0
	Physical Science	103	2	5	5
	Environmental Science	14	2	5	5
	First-year Biology	288	197	13	1
	First-year Chemistry	4	254	258	8
	First-year Physics	13	5	89	75
	Second-year Biology	2	57	44	75
	Second-year Chemistry	0	3	159	299
PHYSICS					
	General Science	44	5	2	1
	Earth Science	13	2	2	0
	Life Science	4	1	2	2

(table continues)

Advanced Science Subgroup	Science Course Taken	Grade During Which Science Was Taken, Grades 9-12			
		9	10	11	12
	Environmental Science	9	5	4	0
	First-year Biology	283	108	9	1
	First-year Chemistry	3	304	92	12
	First-year Physics	0	9	319	72
	Second-year Biology	7	23	17	38
	Second-year Chemistry	0	5	82	40
	Second-year Physics	0	0	9	287
	Other science course	53	26	65	46

*The numbers of students who reported taking a second year course of biology, chemistry, or physics differ from the numbers given for each of the SISS-U.S.A. Advanced Science subgroups due to nonresponse for the individual courses taken.

Approximately the same number of Advanced Chemistry students had taken first-year chemistry in 10th grade as had taken it in 11th grade. Almost twice as many 12th grade Advanced Chemistry students had taken a second-year of chemistry as had 11th grade students. More Advanced Chemistry students than Advanced Biology students reported having studied at least first-year physics.

In the Advanced Physics population, 287 of the respondents reported taking a second-year physics course as 12th graders. The majority of the Physics students reported having studied first-year biology in the 9th grade, first-year chemistry in the 10th grade, and first-year physics in the 11th grade. It is puzzling that 72 of the Advanced Physics students reported taking a first-year physics course in 12th grade. It is possible that these students misinterpreted the item and took "first-year" as being the first *academic* year of studying physics and that they had not taken an introductory first-year physics course prior to enrollment in the advanced course. This situation is possible in many schools if the student has had the required mathematics background, and has had a strong academic performance in prior science course.

Student responses to the item on science course history are presented in Table 15. More Advanced Biology students reported having studied more than five years of science than did Advanced Chemistry or Advanced Physics students. Approximately 60% of the Advanced Chemistry students and more than 75% of the Advanced Physics students reported having studied at least four years of science since 8th grade compared with 45.9% of the Advanced Biology students who reported having studied at least four years of science.

Students were to indicate which subjects they had studied for a FULL year and which subjects they had studied for PART of a year (Table 15). It is possible that the students who reported that they had not studied any science since 8th grade misinterpreted the item requesting information about the student's science course history. Only FULL year responses were totaled since there was no information available as to a quantitative measure of what "PART" of a year meant. In some schools, courses may be offered on semester, trimester, or quarter basis, depending on staff availability, student enrollments, and organization of the school day.

Table 15

Years of Science Studied After 8th Grade: Student Responses by SISS-U.S. Advanced Science Subgroup

	Advanced Science Subgroup					
Years of Science Studied	Biology		Chemistry		Physics	
After 8th Grade	N	%	N	%	N	%
None	36	5.4	24	4.3	26	5.2
One	16	2.4	2	0.4	9	1.8
Two	139	20.8	28	5.0	17	3.4
Three	162	24.2	173	30.6	70	13.9
Four	174	26.0	190	33.6	185	36.9
Five	80	11.9	148	26.2	195	38.8
Six	38	5.7	0	0.0	0	0.0
Seven	9	1.3	0	0.0	0	0.0
Eight	5	0.8	0	0.0	0	0.0
More than eight years	1	0.2	0	0.0	0	0.0
Nonresponding	4		0		0	
Total responding	670		565*		502*	

*The total number of respondents for the Advanced Chemistry and Advanced Physics subgroups represents those students who completed the second administration (Booklet 2).

Educational Aspirations of Students. Students were asked about their education plans after high school and the types of coursework they plan to pursue. The data in Tables 16 and 17 summarize student responses to the item on further education and to the item on types of coursework.

A majority of students in all three advanced science populations indicated an expected further education of at least three to four years (Table 16). A greater percentage of both the Advanced Chemistry and Advanced Physics students reported an expected education of more than four years than did Advanced Biology students. This may reflect a higher self-perceived ability by the Advanced Chemistry and Physics students compared with that by the Advanced Biology students as well as home and peer influence.

Table 16

Amount of Expected Further Education: Student Responses by SISS-U.S. Advanced Science Subgroup

Amount of Further Education	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
Not decided	61	9.5	16	3.0	13	2.7
Not expected	15	2.3	3	0.6	3	0.6
1 - 2 years	39	6.0	15	2.8	2	0.4
3 - 4 years	232	36.0	162	30.0	107	21.8
More than 4 years	298	46.2	344	63.7	365	74.5
Nonresponse	29		22		10	
Total responding	645		540		490	

Note: Total percent may not equal 100 due to rounding.

Approximately 43% of the Advanced Biology students indicated that they would pursue coursework in Science or Applied Science whereas 66% of the Advanced Chemistry students and 69% of the Advanced Physics students indicated this choice (Table 17). About 25% of the Advanced Biology students responded that they would study either Social Science or Business/Commerce while 15% of the Advanced Chemistry students and 16% of the Advanced Physics students marked either of these choices. Indicated choices among the remaining fields of study ranged from a low of 0.4% of the Advanced Physics students for Agriculture to a high of 14.5% of the Advanced Biology students for Business/Commerce. A greater percentage of the Advanced Biology students were undecided or expected no further study in preparation for a career compared with the percentages of students in Advanced Chemistry and Advanced Physics who reported being undecided or expected no further study.

Table 17

Expected Type of Further Education: Student Responses by SISS-U.S. Advanced Science Subgroup

Type of Coursework	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
Not decided	60	9.4	38	7.1	38	7.9
Not expected	17	2.7	2	0.4	0	0.0
Science/Applied Science	270	42.5	350	65.5	333	68.8
Social Science	63	9.9	36	6.7	27	5.6
Business/Commerce	92	14.5	44	8.2	52	10.7
Education/Teacher training	24	3.8	15	2.8	3	0.6
Art/Design/Music	26	4.1	14	2.6	11	2.3
Agriculture	15	2.4	6	1.1	12	0.4
English/Foreign Language	26	4.1	17	3.2	12	2.5
Other	42	6.6	12	2.2	6	1.2
Nonresponse	39		28		16	
Total responding	635		534		484	

Note: Total percent may not equal 100 due to rounding.

Hours Per Week Spent Watching Television. Students were asked to report the number of hours they spent watching television each week. Students in Advanced Biology reported more hours spent watching television per week than did students in Advanced Chemistry or Advanced Physics (Table 18).

Table 18

Hours Per Week Spent Watching Television by SISS-U.S. Advanced Science Subgroup

Hours Per Week Spent Watching Television	Advanced Science Subgroup Biology N	Biology %	Chemistry N	Chemistry %	Physics N	Physics %
Don't watch during week	27	4.2	19	3.5	29	5.9
Some, less than 1 hour	75	11.6	79	14.6	81	16.6
About 1 hour	90	13.9	84	15.6	105	21.5
About 2 hours	135	20.9	110	20.4	97	19.8
About 3 hours	132	20.4	100	18.5	64	13.1
About 4 hours	83	12.8	55	10.2	44	9.0
About 5 hours	40	6.2	36	6.7	26	5.3
6 hours or more	64	9.9	57	10.6	43	8.8
Nonresponding	30		22		11	
Total responding	646		540		489	

Note: Total percent may not equal 100 due to rounding.

Homework: Hours Spent Per Week on All Subjects and on Science. Students were asked to report the number of hours spent on homework for all school subjects and for science. Summaries of these data are presented in Tables 19 and 20, respectively.

On average, the Advanced Physics students reported spending more time per week on all homework than either the Advanced Biology or Advanced Chemistry students.

A greater percentage of both Advanced Chemistry and Advanced Physics students reported spending more time per week on all subjects as well as spending more time on science homework than did the Advanced Biology students (Table 19).

The Advanced Biology students reported spending the least amount of time per week on all homework and on science homework in particular. The Advanced Physics students reported spending the most time per week on homework for all subjects and on science homework in particular (Tables 19 and 20).

Table 19

Hours Per Week Spent on Homework for All Subjects by SISS-U.S. Advanced Science Subgroup

Hours Spent Per Week on Homework -All Subjects	Advanced Science Subgroup: Biology N	Biology %	Chemistry N	Chemistry %	Physics N	Physics %
None assigned	6	0.9	4	0.7	0	0.0
Have, but don't do	37	5.7	29	5.4	20	4.1
Up to 2 hours	184	28.6	126	23.3	81	16.6
Between 2 - 5 hours	211	32.8	148	27.4	100	20.5
Between 5 - 10 hours	132	20.5	117	21.6	138	28.3
Between 10 - 20 hours	66	10.2	95	17.6	118	24.2
More than 20 hours	8	1.2	22	4.1	31	6.4
Nonresponding	30		21		12	
Total responding	644		541		488	

Note: Total percent may not equal 100 due to rounding.

Table 20

Hours Per Week Spent on Science Homework by SISS-U.S. Advanced Science Subgroup

Hours Per Week Spent on Science Homework	Advanced Science Subgroup: Biology N	Biology %	Chemistry N	Chemistry %	Physics N	Physics %
None assigned	51	7.9	43	8.0	13	2.7
Have, but don't do	56	8.7	53	9.8	41	8.4
Up to 2 hours	364	56.4	249	46.1	235	48.1
Between 2 - 5 hours	130	20.2	139	25.7	153	31.3
Between 5 - 10 hours	40	6.2	43	8.0	32	6.5
More than 10 hours	4	0.6	13	2.4	15	3.1
Nonresponding	29		22		11	
Total responding	645		540		489	

Note: Total percent may not equal 100 due to rounding.

Description of Grades So Far in School. Students were asked to indicate which of the choices given best described their grades so far in school. The student responses to this item are presented in Table 21.

Table 21

Student Description of Grades Received in School by SISS-U.S. Advanced Science Subgroup

Grades Received in School	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
Mostly A	122	18.9	207	38.3	209	42.7
About half A and half B	159	24.7	158	29.2	150	30.7
Mostly B	146	22.6	101	18.7	94	19.2
About half B and half C	131	20.3	43	7.9	28	5.7
Mostly C	57	8.8	24	4.4	5	1.0
About half C and half D	25	3.9	8	1.5	3	0.6
Mostly D	5	0.8	0	0.0	0	0.0
Mostly below D	0	0.0	0	0.0	0	0.0
Nonresponding	9		22		11	
Total responding	645		541		489	

Note: Total percent may not equal 100 due to rounding.

Of the Advanced Biology students, 66.2% reported having grades which were mostly B or better. There were 86.2% of the Advanced Chemistry students and 92.6% of the Advanced Physics students who reported grades of mostly B or better. Smaller percentages of students in Advanced Chemistry and Physics reported that their grades were about half B and half C, mostly C, or about half C and half D than did Advanced Biology students.

Years of Mathematics Studied Since Eighth Grade. On average, the Advanced Biology students reported having studied the least numbers of years of mathematics of the three advanced science subsamples (Table 22). The Advanced Physics students reported having studied the most numbers of years of mathematics of the three advanced science subsamples. Descriptions of mathematics courses studied by the U.S. Advanced Science students were not obtained by the SISS instruments.

Table 22

Years of Mathematics Studied After 8th Grade: Student Responses by SISS-U.S. Advanced Science Subgroup

Years of Mathematics Studied After 8th Grade	Advanced Science Subgroup Biology N	 Biology %	 Chemistry N	 Chemistry %	 Physics N	 Physics %
None	0	0.0	0	0.0	0	0.0
One	7	1.1	0	0.0	0	0.0
Two	157	24.3	24	4.4	3	0.6
Three	256	39.6	217	40.2	56	11.5
Four	174	26.9	242	44.8	301	61.7
More than four	52	8.0	57	10.6	128	26.2
Nonresponding	28		22		12	
Total responding	646		540		488	

Education and Occupation Levels of Parents (or Stepparents or Guardians). Students were asked to indicate the highest levels of education completed by their parents (or stepparents or guardians) (Table 23). Of the students who responded to these items, 48.0% of the Advanced Biology students, 48.8% of the Advanced Chemistry students, and 66.1% of the Advanced Physics students indicated that their father (or stepfather or male guardian) had completed college or a higher level of education. In response to the item concerning the highest education level of their mother (or stepmother, or female guardian), 37.1% of the Advanced Biology students, 42.3% of the Advanced Chemistry students, and 56.4% of the Advanced Physics students indicated that their mother (or stepmother, or female guardian) had completed college or a higher level of education.

On the items concerning occupations of parents (or stepparents, or guardians), 43.6% of the Advanced Biology students, 44.4% of the Advanced Chemistry students, and 63.2% of the Advanced Physics students responded that their father (or stepfather, or male guardian) held a professional or executive position (Table 23). On the item concerning the occupation of their mother (or stepmother, or female guardian), 25.6% of the Advanced Biology students, 25.9% of the Advanced Chemistry students, and 35.6% of the Advanced Physics students indicated that the occupation of the mother (or stepmother, or female guardian) was professional or executive.

Table 23

Parental Education Levels and Occupations by SISS-U.S. Advanced Science Subgroup

	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
LEVEL OF EDUCATION						
Father/Stepfather/Male Guardian						
Don't live with father	18	2.8	14	2.6	3	0.6
Grade school	14	2.2	12	2.2	8	1.6
Some high school	38	5.9	25	4.6	19	3.9
High school	143	22.3	114	21.1	61	12.5
Some education after HS	100	15.6	102	18.9	69	14.1
College or higher	308	48.0	264	48.8	323	66.1
Don't know	20	3.1	10	1.8	6	1.2
Nonresponding	33		21		11	
Total responding	641		541		489	
Mother/Stepmother/Female Guardian						
Don't live with mother	4	0.6	7	1.3	0	0.0
Grade school	7	1.1	14	2.6	9	1.8
Some high school	49	7.6	21	3.9	10	2.0
High school	197	30.6	151	27.9	103	21.1
Some education after HS	129	20.0	109	20.1	83	17.0
College or higher	239	37.1	229	42.3	275	56.4
Don't know	19	3.0	10	1.8	8	1.6
Nonresponse	30		21		12	
Total responding	644		541		488	

(table continues)

	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
OCCUPATION						
Father/Stepfather/Male Guardian						
Don't live with father	29	4.6	28	5.2	9	1.8
Semiskilled	92	14.4	58	10.7	29	5.9
Skilled	134	21.0	132	24.4	91	18.6
Clerical/Sales	53	8.3	58	10.7	35	7.2
Prof/Executive	278	43.6	240	44.4	309	63.2
Homemaker	0	0.0	1	0.2	1	0.2
Some other	51	8.0	23	4.3	15	3.1
Nonresponse	37		22		11	
Total responding	637		540		489	
Mother/Stepmother/Female Guardian						
Don't live with mother	9	1.4	13	2.4	4	0.8
Semiskilled	91	14.0	54	10.0	42	8.6
Skilled	44	7.3	40	7.4	43	8.8
Clerical/Sales	145	22.5	121	22.4	100	20.4
Prof/Executive	165	25.6	140	25.9	174	35.6
Homemaker	155	24.0	149	27.5	110	22.5
Some other	33	5.1	24	4.4	16	3.3
Nonresponding	29		21		11	
Total responding	645		541		489	

Note: Total percent may not equal 100 due to rounding.

The data presented in Table 23 raise questions about the accuracy of the students' responses. In particular, the responses to the items "Don't live with father/mother" are not consistent across subgroups for the four questionnaire items. It apears that some students gave different responses across these four items regarding their living with father and/or mother. If a student gave multiple responses for any item, the affected item was excluded from all analyses of that student's data file. There is no way of determining if similar discrepancies are reflected in student responses to other questionnaire items since only the items concerning parental education and occupation contained a highly specific and unique response choice such as "Don't live with father/mother" in all four items.

Number of Books in the Home. The last student questionnaire item related to student home background concerned the number of books in the home. Of the Advanced Biology students who responded to this item, 94.1% indicated that there was at least one bookcase full (26-100 books) in their home (Table 24). About 15% of the Advanced Biology students reported that there was a room full or library (more than 500 books) in their home. Of the Advanced Chemistry students, 95.2% reported at least one bookcase full, and 20.1% indicated that there was a room full of books in their home. About 97% of the Advanced Physics students reported at least one bookcase full in their home, and 28.3% indicated that there was a room full of books in their home.

Table 24

Number of Books in the Home: Student Responses by SISS-U.S. Advanced Science Subgroup

Number of Books in the Home	Advanced Science Subsample					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
None (1-10)	8	1.2	8	1.5	5	1.0
Few (11-25)	28	4.4	18	3.3	9	1.8
About 1 bookcase full (26-100)	150	23.3	96	17.8	67	13.8
About 2 bookcases full (101-250)	189	29.3	142	26.4	120	24.6
About 3 or 4 bookcases full (251-500)	173	26.8	166	30.9	148	30.4
A room full/a library (more than 500)	97	14.7	108	20.1	138	28.3
Nonresponding	30		24		13	
Total responding	644		538		487	

Note: Total percent may not equal 100 due to rounding.

Responses to Items Concerning Student Opinions

Students were asked to respond to 28 statements about science and various aspects of the impact of science on society. Opinionnaire items have been grouped by category: Importance of Science, School Attitudes, Facility of Science. and Jobs in Science (Table 25). Response choices for these items were "Agree," "Disagree," and "Uncertain". Results have been given in percent of students responding to the individual item. Numbers of students responding to each item have been indicated.

Table 25

SISS-U.S. Advanced Science Student Responses to Opinionnaire Items (Percent of Students by Advanced Science Subgroup)

ATTITUDES TOWARD SCIENCE

Science is useful for solving the problems of everyday life.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	68.2	76.4	78.7
Disagree	14.6	11.0	8.0
Uncertain	17.2	12.6	13.3
Nonresponding	30	24	12
Total responding	644	538	488

Science has ruined the environment

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	5.6	8.7	7.8
Disagree	79.0	75.9	74.2
Uncertain	15.4	15.4	18.0
Nonresponding	32	23	12
Total responding	644	539	488

(table continues)

Science is very important for a country's development.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	91.9	93.7	95.7
Disagree	1.9	1.3	2.5
Uncertain	6.2	5.0	1.8
Nonresponding	33	23	11
Total responding	641	539	489

Money spent on science is well worth spending.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	69.1	76.3	77.2
Disagree	7.2	2.4	2.5
Uncertain	23.8	21.3	20.3
Nonresponding	31	22	13
Total responding	643	540	487

Much of the anxiety in modern society is due to science.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	24.3	29.1	32.0
Disagree	37.1	39.7	48.8
Uncertain	38.6	34.5	28.3
Nonresponding	32	25	11
Total responding	642	537	489

(table continues)

People who understand science are better off in our society.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	44.0	58.3	59.4
Disagree	25.0	20.4	17.8
Uncertain	30.9	21.3	22.7
Nonresponding	31	22	12
Total responding	643	540	488

Scientific inventions improve our standard of living.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	89.9	93.5	92.2
Disagree	2.8	1.1	1.8
Uncertain	7.6	5.4	5.9
Nonresponding	31	22	12
Total responding	643	540	488

Scientific inventions have increased tensions between people.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	43.9	42.9	40.0
Disagree	27.1	29.9	34.8
Uncertain	29.1	27.3	25.2
Nonresponding	31	23	12
Total responding	643	539	488

(table continues)

Science will help make the world a better place in the future.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	64.7	70.2	71.6
Disagree	6.4	3.5	6.3
Uncertain	28.9	26.3	22.1
Nonresponding	33	22	11
Total responding	641	540	489

Scientific discoveries do more harm than good.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	7.8	7.4	6.6
Disagree	66.3	66.3	69.4
Uncertain	25.9	26.3	24.0
Nonresponding	29	22	11
Total responding	643	540	489

Science and technology are the cause of many of the world's problems.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	31.1	28.7	29.1
Disagree	45.0	48.0	54.0
Uncertain	23.9	23.3	16.9
Nonresponding	34	22	14
Total responding	640	540	486

(table continues)

Science is relevant to everyday life.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	77.4	80.8	80.9
Disagree	7.2	7.1	6.8
Uncertain	15.4	12.1	12.3
Nonresponding	31	24	12
Total responding	643	538	488

Working in a science laboratory would be an interesting way to earn a living.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	50.1	59.5	50.1
Disagree	29.7	20.6	23.9
Uncertain	20.2	19.8	26.0
Nonresponding	40	33	15
Total responding	634	529	485

In the future, most jobs will require a knowledge of science.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	67.0	72.4	67.0
Disagree	10.9	10.4	13.9
Uncertain	22.1	17.3	19.1
Nonresponding	31	23	11
Total responding	643	539	489

(table continues)

It is important to know science in order to get a good job.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	21.7	26.7	28.2
Disagree	57.3	49.3	55.2
Uncertain	21.0	24.1	16.6
Nonresponding	31	22	11
Total responding	643	540	489

In my future career, I would like to use the science I learned at school.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	52.7	71.5	79.1
Disagree	24.2	12.0	12.9
Uncertain	23.1	16.5	16.0
Nonresponding	29	22	11
Total responding	645	540	489

I would like to become a science teacher when I leave school.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	2.2	3.0	2.9
Disagree	90.4	87.4	88.3
Uncertain	7.5	9.6	8.8
Nonresponding	31	22	11
Total responding	643	540	489

(table continues

ATTITUDES TOWARDS SCHOOL

I find school challenging.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	68.6	67.0	66.1
Disagree	21.1	22.4	21.6
Uncertain	10.2	10.6	12.3
Nonresponding	28	22	13
Total responding	644	540	487

School is not very enjoyable.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	32.5	25.7	21.4
Disagree	50.7	60.7	57.9
Uncertain	16.8	13.5	20.7
Nonresponding	31	22	12
Total responding	643	540	488

I am bored most of the time in school.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	36.8	36.8	31.7
Disagree	50.9	54.3	50.9
Uncertain	12.3	8.9	17.4
Nonresponding	31	22	11
Total responding	643	540	489

(table continues)

There are many school subjects I don't like.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	44.2	37.7	35.5
Disagree	47.4	55.3	55.3
Uncertain	8.4	7.0	9.2
Nonresponding	31	22	11
Total responding	643	540	489

I generally dislike my schoolwork.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	33.9	29.2	28.1
Disagree	52.7	57.7	56.8
Uncertain	13.4	13.1	15.2
Nonresponding	31	21	11
Total responding	643	541	489

ATTITUDES TOWARD SCHOOL SCIENCE

Science is an enjoyable school subject.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	64.9	75.4	83.6
Disagree	19.6	13.7	9.2
Uncertain	15.5	10.9	11.3
Nonresponding	30	21	12
Total responding	644	541	488

(table continues)

The science taught at school is interesting.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	64.9	75.4	83.6
Disagree	19.6	13.7	9.2
Uncertain	15.5	10.9	11.3
Nonresponding	30	21	12
Total responding	644	541	488

Science is a difficult subject.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	52.7	51.6	45.8
Disagree	37.9	36.7	39.1
Uncertain	9.4	11.7	15.1
Nonresponding	38	24	16
Total responding	636	538	484

Science is difficult when it involves calculations.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	56.3	67.3	20.7
Disagree	29.7	55.9	70.0
Uncertain	14.0	8.6	9.2
Nonresponding	30	24	12
Total responding	644	538	488

(table continues)

Science is difficult when it involves handling apparatus.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	18.7	14.6	12.7
Disagree	69.5	77.8	79.6
Uncertain	11.8	7.6	7.8
Nonresponding	30	22	11
Total responding	644	540	489

There are too many facts to learn in science.

	Advanced Science Subgroup		
	Biology	Chemistry	Physics
Agree	37.0	31.6	22.2
Disagree	50.3	55.6	62.8
Uncertain	12.7	12.8	15.0
Nonresponding	30	24	12
Total responding	644	538	488

Note: Total percent for each item may not equal 100 due to rounding.

Higher percentages of Advanced Science students agreed than disagreed that science is useful for solving the problems of everyday life, is very important for a country's development, that money spent on science is worth spending, that science will help make the world a better place in the future (Table 25). More students in each subgroup agreed that scientific inventions have increased tensions between people, that people who understand science are better off in our society, and that scientific inventions improve our standard of living than disagreed. Of the three subgroups, in general, lower percentages of the Advanced Biology students were in agreement with the statements than were either Advanced Chemistry or Advanced Physics students.

More Advanced Science students disagreed than agreed that science has ruined the environment, that much of the anxiety in modern society is due to science, that scientific discoveries do more harm than good, and that science and technology are the cause of many of the world's problems. A higher percentage of Advanced Biology students disagreed that science has ruined the environment than did Advanced Chemistry or Advanced Physics students.

Higher percentages of Advanced Science students agreed that they found school challenging than disagreed. More Advanced Science students disagreed that school is not very enjoyable, that they are bored in school most of the time, that there were many school subjects they didn't like, or that they generally disliked their schoolwork than agreed with the statements.

More Advanced Physics students agreed that science is an enjoyable school subject, that science taught at school is interesting, and that science is difficult when it involves calculations than did Advanced Biology or Advanced Chemistry students.

A majority of all three subgroups agreed that science is a difficult subject and disagreed that there are too many facts to learn in science.

Although most Advanced Science students agreed that, in the future, most jobs will require a knowledge of science, higher percentages of the students disagreed that it is important to know science in order to get a good job than agreed. Most of the students agreed that they would like to use the science learned at school in a future career. Very few of the Advanced Science students agreed that they would like to become a science teacher when they leave school.

Background Characteristics of Teachers

The teachers of the classes were asked to complete a 44 item questionnaire designed to obtain data about the teacher's educational background, teaching experience, certification, salary, access to and use of computers, membership in science teacher or science associations, reading of academic journals related to teaching and to science subjects, time spent in school and out of school in preparation for classes taught, determinants of the curriculum (e.g., syllabus or text), teaching methods used (e.g., lecture or question-and-answer), and means of evaluating student performance (e.g., use of standardized test or teacher-prepared test, homework, and laboratory work).

Responses were obtained from 43 Advanced Biology teachers, 38 Advanced Chemistry teachers, and 34 Advanced Physics teachers. Only those teacher characteristics found to be associated with SISS-U.S. advanced science achievement have been described in detail.

Teacher Age

Approximately 71% of the SISS-U.S. Advanced Science teachers were at least 38 years old (Table 26). The modal age range for all subgroups was 38-47 years.

Table 26

Ages of SISS-U. S. Advanced Science Teachers by Subgroup

	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
Age Range in Years	N	%	N	%	N	%
27 years or younger	3	7.0	2	5.6	3	9.1
28 - 37 years	7	16.3	8	22.2	9	27.3
38 - 47 years	22	51.2	14	38.9	12	36.4
48 - 57	8	18.6	8	22.2	6	18.2
Age 58 or older	3	7.0	4	11.1	3	9.1
Nonresponding	0		2		1	
Total responding	43		36		33	

Note: Total percent may not equal 100 due to rounding.

Teacher Education After Secondary School

More than 95% of the teachers reported that they had completed at least between four to six years of education after secondary school (Table 27). A greater percentage of the Advanced Physics teachers compared with Advanced Biology or Advanced Chemistry teachers reported completing more than six years of education after secondary school.

Table 27

Postsecondary Education of SISS-U.S. Advanced Science Teachers by Subgroup

	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
Postsecondary Education	N	%	N	%	N	%
No further education	0	0.0	0	0.0	0	0.0
Up to 2 years	1	2.3	1	2.6	0	0.0
Between 2 - 4 years	1	2.3	0	0.0	0	0.0
Between 4 - 6 years	20	46.5	21	55.6	13	38.2
More than 6 years	21	48.8	16	42.1	21	61.8
Nonresponding	0		0		0	
Total responding	43		38		34	

Note: Total percent may not equal 100 due to rounding.

Postsecondary Study of Science Subjects

At least 50% of each Advanced Science teacher population reported having studied science subjects for at least between 25-50% of their postsecondary education (Table 28). A greater percentage of the teachers of Advanced Biology or Advanced Chemistry reported having studied science subjects for more than 50% of their postsecondary education.

Table 28

Postsecondary Study of Science Subjects of SISS-U.S. Advanced Science Teachers by Subgroup

	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
Postsecondary Science Study	N	%	N	%	N	%
No further education	0	0.0	0	0.0	0	0.0
No study at college	1	2.3	0	0.0	0	0.0
25 % or less	1	2.3	0	0.0	2	5.9
Between 25 - 50 %	14	32.6	16	43.2	15	44.1
More than 50 %	27	62.8	21	56.8	17	50.0
Nonresponding	0		1		0	
Total responding	43		37		34	

Teacher Experience

The modal range of teaching experience for the SISS-U.S. Advanced Science teachers was between 10 and 20 years (Table 29). A greater percentage of Advanced Biology or Advanced Physics teachers compared with Advanced Chemistry teachers reported having taught for between 20 and 30 years. More Advanced Chemistry teachers reported having taught for more than 30 years than did Advanced Biology or Advanced Physics teachers.

Table 29

Years of Teaching Experience of SISS-U.S. Advanced Science Teachers by Subgroup

	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
Teaching Experience	N	%	N	%	N	%
Up to 5 years	3	7.1	3	7.9	4	12.1
Between 5 - 10 years	6	14.3	4	10.5	4	12.1
Between 10 - 20 years	20	47.6	19	50.0	10	30.3
Between 20 - 30 years	13	31.0	7	18.4	12	36.4
More than 30 years	0	0.0	5	13.2	3	9.1
Nonresponding	1		0		1	
Total responding	42		38		33	

Note: Total percent may not equal 100 due to rounding.

Table 30

Membership in Science Teacher or Science Association of SISS-U.S. Advanced Science Teachers by Subgroup

Member of Science Teacher or Science Association	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
Yes	27	62.8	20	54.1	23	67.7
No	16	37.2	17	46.0	11	32.4
Nonresponding	0		1		0	
Total responding	43		37		34	

Note: Total percent may not equal 100 due to rounding.

Membership in Science Teacher or Science Association

More than 61% of all SISS-U.S. Advanced Science teachers reported having membership in a science teacher association (Table 30).

Importance of Prescribed Textbook in Determining What Is Taught

Most of the Advanced Science teacher reported that the prescribed textbook was of some importance in determining what they teach (Table 31).

Table 31

Importance of Prescribed Textbook in Determining What Is Taught: Responses of SISS-U.S. Advanced Science Teachers by Subgroup

Importance of Prescribed Textbook	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
Very important	14	32.6	7	18.9	4	11.8
Some importance	20	46.5	24	64.9	19	55.9
Little importance	8	18.6	4	10.8	3	8.8
No importance	0	0.0	0	0.0	3	8.8
Does not apply	1	2.3	2	5.4	5	14.7
Nonresponding	0		1		0	
Total responding	43		37		34	

Note: Total percent may not equal 100 due to rounding.

External Examinations That Students Will Have to Take

More Advanced Biology teachers reported that external exams were very important in determining what was taught than did Advanced Chemistry or Advanced Physics teachers (Table 32). More Advanced Chemistry and Advanced Physics teachers reported placing some importance on external exams than did Advanced Biology teachers.

Table 32

Importance of External Examinations That Students Will Have to Take: Responses of SISS-U.S. Advanced Science Teachers by Subgroup

Importance of External Examinations	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
Very important	14	33.3	7	19.4	6	17.7
Some importance	19	45.2	24	66.7	20	58.8
Little importance	6	14.3	4	11.1	7	20.6
No importance	3	7.1	1	2.8	0	0.0
Does not apply	0	0.0	0	0.0	1	2.9
Nonresponding	1		2		0	
Total responding	42		36		34	

Note: Total percent may not equal 100 due to rounding.

Use of Teacher-made Essay Tests in Assessing Student Work

More than 62% of the SISS-U.S. Advanced Science teachers reported that they use teacher-made essay tests either occasionally or frequently in assessing student work (Table 33).

Table 33

Frequency of Using Teacher-made Essay Tests in Assessing Student Work: Responses of SISS-U.S. Advanced Science Teachers by Subgroup

Use of Teacher-made Essay Tests	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
Frequently	16	37.2	9	24.3	9	26.5
Occasionally	22	51.2	14	37.8	14	41.2
Rarely	3	7.0	13	35.1	9	26.5
Never	2	4.7	1	2.7	2	5.9
Nonresponding	0		1		0	
Total responding	43		37		34	

Note: Total percent may not equal 100 due to rounding.

Use of Performance on Homework Assignments in Assessing Student Work

About 55% of all SISS-U.S. Advanced Science teachers reported frequently using performance on homework assignments to assess student work (Table 34). A greater percentage of Advanced Biology teachers reported rarely using homework for assessment of student work than Advanced Chemistry and Advanced Physics teachers.

Table 34

Frequency of Using Performance on Homework Assignments in Assessing Student Work: Responses of SISS-U.S. Advanced Science Teachers by Subgroup

Use of Homework Assignments	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
Frequently	20	46.5	21	56.8	22	64.7
Occasionally	9	20.9	12	32.4	6	17.7
Rarely	13	30.2	3	8.1	6	17.7
Never	1	2.3	1	2.7	0	0.0
Nonresponding	0		1		0	
Total responding	43		37		34	

Note: Total percent may not equal 100 due to rounding.

Table 35

Frequency of Using Performance on Laboratory Exercises and/or Projects in Assessing Student Work: Responses of SISS-U.S. Advanced Science Teachers by Subgroup

Use of Laboratory Exercises and/or Projects	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
	N	%	N	%	N	%
Frequently	25	59.5	34	91.9	23	67.7
Occasionally	16	38.1	3	8.1	8	25.5
Rarely	1	2.4	0	0.0	3	8.8
Never	0	0.0	0	0.0	0	0.0
Nonresponding	1		1		0	
Total responding	42		37		34	

Note: Total percent may not equal 100 due to rounding.

Use of Performance on Laboratory Exercises and/or Projects

More than 72% of the SISS-U.S. Advanced Science teachers reported frequently using performance on laboratory exercises and/or projects in assessing student work (Table 35).

Background Characteristics of Schools

The school administrators were asked to respond to a 15-item questionnaire designed to obtain information about the school community, school organization, minimum years of mathematics and science required for graduation from high school, number of rooms equipped as science laboratories, number of laboratory assistants, source of funding for operation costs, monies allocated for science materials and resources, existence of parent-teacher committee, and existence of a committee that plans science activities.

Some schools selected for testing were eligible for testing in more than one science subject. For example, a school might have been eligible for testing in Advanced Biology and Advanced Physics. For schools so affected by multiple testing, only one School Questionnaire was completed by the building administrator. The information for that school was entered in all applicable Advanced Science subgroup files. Therefore, the number of school administrators who completed the School Questionnaire is less than the number of teacher and classes involved in the SISS-U.S. testing (Table 5, page 49). While "duplicate" data regarding a specific school testing in more than one advanced science subject may occur in an aggregated file of *all* SISS-U.S. Advanced Science sample schools, the problem of such duplication does not occur in disaggregated files for the individual Advanced Science subgroups.

School Location

Of the schools in which the SISS testing was carried out, 72% of the responding administrators reported being in a nonmetropolitan area (Table 36).

Table 36

Location of Schools in SISS-U.S. Advanced Science Subgroups

	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
Location	N	%	N	%	N	%
Inner urban part of a metropolitan area	3	7.7	5	13.9	5	15.2
Outer urban/suburban part of a metropolitan area	12	30.8	5	13.9	16	48.5
Urban/suburban area but NOT part of a metropolitan area	13	33.3	13	36.1	11	33.3
Rural area	11	28.2	13	36.1	1	3.0
Nonresponding	1		1		0	
Total Responding	39		36		33	

Note: Total percent may not equal 100 due to rounding.

More than 60% of the schools in either the Advanced Biology or the Advanced Chemistry subgroups were located in nonmetropolitan areas (Table 36). More than 60% of the schools in the Advanced Physics subgroup were located in metropolitan areas.

Area Population

About 65% of the schools in the Advanced Biology subgroup were situated in areas with populations of at least 10,000 people (Table 37). More than 80% of schools in either the Advanced Chemistry or Advanced Physics subgroups were in areas with populations greater than 10,000 people. A greater percentage of schools in the Advanced Biology subgroup was in areas having a population of less than 10,000 than was that of schools in either the Advanced Chemistry or Advanced Physics subgroups.

Table 37

Area Population of SISS-U.S. Advanced Science School Locations by Subgroup

	Advanced Science Subgroup					
	Biology		Chemistry		Physics	
Population	N	%	N	%	N	%
More than 1,000,000	2	5.0	1	2.7	4	12.5
100,000 - 1,000,000	5	12.5	5	13.5	6	18.8
10,000 - 100,000	19	47.5	24	64.9	21	65.6
1,000 - 10,000	12	30.0	7	18.9	1	3.1
Less than 1,000	2	5.0	0	0.0	0	0.0
Nonresponding	0		0		1	
Total responding	40		37		32	

Note: Total percent may not equal 100 due to rounding.

Minimum Years of Science Required for Graduation From High School

Of the Advanced Biology subgroup of schools, 69% required two years of science and 18% required three years of science for graduation from high school. About 76% of the schools in the Advanced Chemistry subgroup required two years of science and 16% required three years of science for graduation from high school. Of the Advanced Physics subgroup of schools, 50% required two years of science and 34% required three years of science for graduation from high school.

Minimum Years of Mathematics Required for Graduation From High School

More than 60% of the schools in the Advanced Biology subgroup required two years of mathematics and 39% required three years of mathematics for graduation from high school. Of the Advanced Chemistry subgroup of schools, 68% required two years of mathematics and 27% required three years of mathematics for graduation from high school. About 29% of the schools in the Advanced Physics subgroup required two years of mathematics, but 68% of the schools required three years of mathematics for graduation from high school.

Percent of Laboratory Use for Science Instruction

More than 80% of the schools in all SISS-U.S. Advanced Science subgroups reported more than 60-80% use per week of laboratory rooms for science instruction.

Tests of Stated Hypotheses

SISS-U.S. Advanced Science Student Achievement on SISS Science Tests

Each student in the subpopulations of the SISS-U.S. Advanced Science sample was given a science test appropriate for the course in which the student was enrolled. The Advanced Biology and the Advanced Chemistry tests each contained 25 international test items and five U.S. national option items. The Advanced Physics test contained 26 international items and four U.S. national items. Table 38 presents a summary of the student scores on the international items and on the total 30 items of the respective tests.

Table 38

SISS-U.S. Advanced Science Student Achievement on SISS Science Tests by Subgroup

	SISS-U.S.A. Total Test*			SISS International Common Items **		
	Bio	Chem	Phys	Bio	Chem	Phys
Mean Score	12.7	11.1	13.8	9.9	9.3	11.4
SD	5.0	5.0	4.8	3.4	3.1	5.0
Mean % Correct	42.5	37.0	45.9	39.4	37.3	43.9
International Mean % Correct***	-	-	-	52.2	49.7	50.1
Nonresponding	2	3	2	2	3	2
Total responding	674	562	500	674	562	500

*International and U.S. optional items

** 25 items for Biology and Chemistry; 26 items for Physics

*** The international mean % correct has been corrected for the common items only. Data for international results were obtained from IEA Memorandum 99.

All three SISS-U.S. Advanced Science subsamples had mean scores below the international mean for each science subject (Table 38). Scores on the 30 item tests were somewhat higher than those for the international set of items which may be inferred that the U.S. national option items were somewhat easier questions for the U.S. students. The higher mean score on the 30 items was expected since the optional test items were chosen to match U.S. curricula. Analyses using *t*-tests for the equality of subgroup mean scores with the international mean scores for each subject indicated that each of the SISS-U.S. Advanced Science subgroup mean score was significantly different from the international mean for the subject (significant at $p < .001$).

The achievement scores of the SISS-U.S. Advanced Science students on the 25 international common items by grade level are presented in Tables 39, 40, and 41.

In the Advanced Biology sample, 12th grade students scored somewhat higher than did 11th grade and 10th grade students on both the 30 item test and on the 25 international set of items (Table 39). The 12th grade Advanced Biology students had reported having studied more years of science than had the 10th and 11th grade students (Table 15, page 73). The additional science study may have provided the 12th grade students with more information relevant to the test items than was possessed by the 10th and 11th grade students. For example, many second-year biology curricula include detailed study of cellular processes as osmosis, diffusion, active transport, tricarboxylic cycle, glycolysis, protein synthesis, and the metabolic pathways of proteins, carbohydrates, and lipids. Understanding of such topics requires a background in chemistry as well as biology. Given the general scheme of secondary school science programs (Miller, 1985) in which first-year biology is studied in the 10th grade and chemistry is studied in the 11th grade, it is likely that the SISS-U.S. Advanced Biology 12th grade students had studied both biology and chemistry and that this was not the case for most of the 10th and 11th grade students (see Table 14, page 71).

Table 39

SISS-U.S. Advanced Biology: Science Achievement Scores by Grade Level (Based on 25 International Common Items)

		Grade Level		
	All	10	11	12
Mean score	9.9	8.2	9.9	10.5
SD	4.3	3.1	4.0	4.4
Mean % Correct	39.4	33.0	39.7	41.9
Nonresponding	2	1	0	1
Total responding	674	134	173	361

Note: 6 Advanced Biology students had not indicated their grade level and are not included in the above data set pertaining to specific grade level but are included in overall Advanced Biology scores which do not discriminate by grade level.

In the SISS-U.S. Advanced Chemistry sample, the 11th grade students had higher scores than did the 12th grade students (Table 40). It may be that the 11th grade students had been accelerated in their science studies and had taken first-year chemistry in the 10th grade (Table 14, page 71). These students may also have been preparing for the College Board Achievement Test in Chemistry (administered in May and June of the academic year).

Table 40

SISS-U.S. Advanced Chemistry: Science Achievement Scores by Grade Level (Based on 25 International Common Items)

		Grade Level		
	All	10	11	12
Mean score	8.7	-	9.5	8.3
SD	4.8	-	4.6	4.4
Mean % Correct	34.9	-	38.0	33.3
Nonresponding	3	0	2	1
Total responding	562	0	186	376

Preparation for the College Board test may have reinforced the chemistry learned prior to the time of the SISS testing, thus resulting in scores that were higher than those of the 12th grade students. (Seniors in high school generally take the College Board Achievement Tests before January of the senior year in order to have the scores available for college admissions applications).

As with the Advanced Chemistry students, the 11th grade Advanced Physics students had higher achievement scores compared with the 12th grade students (Table 41). These students also may have been accelerated in their science studies (see Table 14, page 71) and also may have been preparing for the College Board Achievement Test in Physics.

Table 41

SISS-U.S. Advanced Physics: Science Achievement Scores by Grade Level
(Based on 26 International Common Items)

		Grade Level		
	All	10	11	12
Mean score	11.4	8.5	11.9	11.4
SD	4.5	0.0	4.0	4.5
Mean % Correct	43.9	32.7	45.9	43.8
Nonresponding	0	0	0	0
Total responding	500	2	50	448

SISS-U.S. Advanced Science Student Achievement on SISS Mathematics Test

The Mathematics Test consisted of 15 international multiple choice items that tested basic concepts appropriate for students taking a second year/advanced science course. All SISS-U.S. Advanced Science students were given the same Mathematics Test (Appendix B, Advanced Science Student Booklet 2). The mean scores for each of the Advanced Science subsamples are presented in Table 42.

The Physics students had the highest mean score on the SISS Mathematics Test of the three U.S. Advanced Science subgroups, followed by the Chemistry and Biology students, respectively. This was expected since the

Physics students reported having studied more full years of mathematics than had either the Chemistry or Biology students (Table 22, page 79).

Table 42

SISS-U.S Advanced Science Student Achievement on the SISS Mathematics Test by Subgroup

		Statistics for Mathematics Test		
Subgroup	N	Mean Score	SD	Mean % Correct
Biology	648	8.03	3.2	53.5
Chemistry	542	10.4	3.0	69.4
Physics	489	12.4	2.2	82.3

Table 43

Pearson Product-Moment and Partial Correlation Coefficients for U.S. Advanced Science Student Achievement With Scores on the SISS Mathematics Test by Subgroup

Advanced Science Subgroup	Pearson Product-Moment Coefficient	Partial Correlation Coefficient
Biology	.5725*	.5380*
Chemistry	.5840*	.3971*
Physics	.3989*	.2974*

*Significant at $p < .001$

The Pearson product-moment and partial correlation coefficients (controlling for home background, teacher and school variables) for student science achievement scores with scores on the Mathematics Test are presented in Table 43. Across science subjects, the student achievement scores on the Mathematics Test of the SISS testing program are significantly and positively correlated with student science achievement scores. The lower degree of association between science achievement and the Mathematics Test score noted for the Advanced Chemistry and Physics subgroups compared with that for the

Advanced Biology probably reflects the more homogeneous background of the chemistry and physics students regarding mathematics (see Table 22, page 79).

U.S. Advanced Science Student Achievement on SISS Word Knowledge Test

The Word Knowledge Test consisted of 30 dichotomous response items ("same" or "opposite") that were appropriate for the Advanced Science student population. All SISS-U.S. Advanced Science subsamples were given the same Word Knowledge Test. Student achievement scores on the Word Knowledge Test are presented in Table 44.

Table 44

U.S. Advanced Science Student Achievement on the SISS Word Knowledge Test by Subgroup

		Statistics for Word Knowledge Test		
Subgroup	N	Mean Score	SD	Mean % Correct
Biology	642	11.3	3.0	37.7
Chemistry	541	12.4	2.7	41.5
Physics	478	13.5	2.4	44.9

Verbal ability has been identified as a determinant of academic ability (Neie, 1972; Pari, 1973; Tate and Burkman, 1983). As such, based on the data in Table 44, one may infer that the Physics students were the most able students and the Biology students were the least able students of the U.S. Advanced Science sample regarding overall academic ability.

The Pearson product-moment and partial correlation coefficients (controlling for home background, teacher and school variables) for student science achievement scores with scores on the Word Knowledge Test are presented in Table 45. Across science subjects, the U.S. Advanced Science student achievement scores on the Word Knowledge Test of the SISS testing program are significantly and positively correlated with student science achievement scores.

The lower degree of association of student science achievement with scores on the Word Knowledge Test for the U.S. Advanced Chemistry and Physics subgroups compared with that for the Advanced Biology subgroup is most likely a reflection of the greater degree of homogeneity of student abilities within the chemistry and physics subgroups. It may be inferred from the responses regarding student descriptions of grades received in school (Table 21, page 78) that, as groups, the Advanced Chemistry and Advanced Physics students are more able students compared with the Advanced Biology students. Comparisons of student scores by Advanced Science subgroup on both the Mathematics and Word Knowledge tests also imply that the Advanced Chemistry and Physics students, as groups, are more able than are the Advanced Biology students as a group.

Table 45

Pearson Product-Moment and Partial Correlation Coefficients for U.S. Advanced Science Student Achievement With Scores on the SISS Word Knowledge Test by Subgroup

Advanced Science Subgroup	Pearson Product-Moment Coefficient	Partial Correlation Coefficient
Biology	.4811*	.4276*
Chemistry	.3859*	.2169*
Physics	.3803*	.2529*

*Significant at p < .001

Student, Teacher, and School Factors Associated With High Science Achievement Across Science Subjects

Across science subjects, the common student factors identified as being associated with high science achievement were *ability* (determined by student scores on the Mathematics and Word Knowledge Tests), *the amount of physical science studied* (determined by student responses to questions regarding science course history, grades 9-12), *interest in science* (determined by student responses to opinionnaire items), and *student attitude toward science* (determined by student responses to opinionnaire items). Partial correlation coefficients (controlling for home background, teacher and school variables) for the above factors with student science achievement are presented in Table 46. The greatest degree of association between each of the factors and student achievement is observed for the SISS-U.S. Advanced Biology subgroup. This subgroup for each of the factors compared with that for the other subgroups (see Table 25, page 83, and Appendix H, page 248.

Table 46

Partial Correlation Coefficients for Student Factors Common to All SISS-U.S. Advanced Science Subgroups With Science Achievement

Student Factor	Subgroup	Partial Correlation Coefficient
ABILITY	Biology	.4466**
	Chemistry	.4225**
	Physics	.2931**
AMOUNT OF PHYSICAL SCIENCE STUDIED	Biology	.2847**
	Chemistry	.1114*
	Physics	.2223**
INTEREST IN SCIENCE	Biology	.2645**
	Chemistry	.1089*
	Physics	.1438*
ATTITUDE TOWARD SCIENCE	Biology	.2765**
	Chemistry	.1833*
	Physics	.1109*

*Significant at $p < .05$
**Significant at $p < .001$

There were no teacher or school factors associated with high science achievement that were common across all advanced science subjects. Partial correlation coefficients (controlling for home background, student and school variables) for significant teacher variables within each SISS-U.S. Advanced Science subgroup are presented in Table 47.

Table 47

Partial Correlation Coefficients for Significant Teacher Variables Within SISS-U.S. Advanced Science Subgroups

Subgroup	Teacher Variable	Partial Correlation Coefficient	p <
BIOLOGY	Importance placed on prescribed text in determining curriculum (recoded: very important = 1 little importance = 3)	.1056	.05
	Frequent use of teacher-made essay tests	.1170	.05
	Use of performance on homework to assess student work	.1108	.05
	Use of performance on lab/project to assess student work	.0864	.05
	Frequent use of lecture	.0840	.05
CHEMISTRY	Postsecondary study of science	.1365	.05
	Teaching experience	.1845	.05
	Membership in science teacher or science association	.1304	.05
	Importance placed on prescribed textbook in determining curriculum (recoded: very important = 1 little importance = 3)	.3101	.05

(table continues)

Subgroup	Teacher Variable	Partial Correlation Coefficient	p<
	Frequent use of teacher-made essay test	.1161	.05
	Use of performance on lab/project to assess student work	.1711	.05
PHYSICS	Importance of external exam that students must take in determining curriculum	.2078	.001

In both the SISS-U.S. Advanced Biology and Chemistry subgroups, little importance (as perceived by the teacher) of the prescribed textbook was positively and significantly associated with student achievement (Table 47). One inference of this finding is that the SISS-U.S. Advanced Science students who had the higher achievement scores were presented with curricula not "driven" by a prescribed text. Unfortunately, the SISS-U.S. teacher questionnaire did not address the influence of supplemental texts/journals/teacher-prepared materials, school district and/or state mandated curricula in determining what is to be taught. Thus, there is no factor discernible from the data set that can be identified as being critical in the determination of curricula for the SISS-U.S. Advanced Biology and Chemistry subgroups.

For the SISS-U.S. Advanced Physics subgroup, the importance of an external exam that students must take emerged as the only teacher-related variable in determining curriculum (Table 47). Considering that 20 of the 34 SISS-U.S. Advanced Physics classes were identified as Advanced Placement, it is likely that the responses of teachers of the AP Physics classes influenced the overall results for this item. (AP teachers are more likely to "teach to the test" since student scores on the AP exam determine whether or not advanced standing or a college course waiver is granted). For both the SISS-U.S. Advanced Biology and Chemistry subgroups, the use of teacher-made essay tests was identified as being a significant factor associated with student achievement. Essay tests that require more than one or two sentences to be answered allow the teacher to assess application and synthesis of concepts rather than simple recall of information. It may be that those students whose teachers frequently use teacher-made essay tests had a more comprehensive understanding of the subject matter and were thus able to use the knowledge in answering the SISS test items.

Also for both U.S. Advanced Biology and Chemistry subgroups, the use of performance on lab/project to assess student work was associated with student achievement. An implication of this finding is that laboratory work in Advanced Biology and Chemistry contributes to student achievement. The relative strength of the association with Biology achievement is much weaker than that for Chemistry achievement (Table 47). One factor contributing to the "strength" of the Chemistry association may be that chemical concepts and laboratory work tend to be more abstract than biological laboratory activities. Students may have experienced many of the activities in a biology lab prior to the course, either in previous courses or in non-school settings such as museums and science centers, whereas the activities in a chemistry lab are not easily carried out without special materials (the chemicals themselves as well as glassware, fume hoods, balances, and safety equipment). Placing emphasis on student performance on a chemistry lab/project in assessing student work is an indication that the lab/project itself is a factor in acquiring knowledge about chemical processes. Not that biology lab work is not important, but the materials used in biology are far more familiar to most students than are those used in chemistry. It is also easier for a student to gain information for a biology lab/project from outside readings than it is to do so for a chemistry lab/project.

Biology tends to be a more verbal science than chemistry and physics, which tend to be more mathematical. A student with an adequate mathematics background can derive most of the formulas used in chemistry and physics, given that the student is somewhat familiar with the terminology. In biology, however, the number of new terms that is introduced in an introductory level course is well over 2400--words that are specific to biology and have no transfer to or from the other science areas. For example, terms such as heat, temperature, pressure, elasticity, density, kinetic energy, electromagnetic attraction/repulsion, force, and joule are used in both chemistry and physics courses. (They may be used also in advanced biology courses that emphasize biochemical and biophysical concepts). But terms such as chemiosmotic regulation, active transport, biomass, mutualism, commensalism, adenosine mono-, di-, and triphosphate, beta oxidation, hydrogen transport mechanism, cytochromes, transamination, meiosis, *Drosophila melanogaster*, synapsis, photophosphorylation, nondisjunction, and immunoglobin are related very specifically to living organisms only. Many of the biological concepts are also interrelated and may have fine distinctions in their definitions and applications. Students in elementary school are often familiar with terms such as "heat," "temperature," "pressure," "magnetism," "electricity," and "force," but are not as familiar with the more sophisticated biological concepts and terms as those given above. Thus, homework in biology is important for the student to become familiar with the terminology of the science as well as with the biological processes.

The frequent use of lecture as a significant factor--although with a weak association--of student achievement is not surprising to this researcher given that lecturing is fairly efficient for the *transmission* of information from one party to another. The *effectiveness* of the lecture method for student learning and mastery of the information is another situation not to be addressed here.

For the SISS-U.S. Advanced Chemistry subgroup, postsecondary study of science, teaching experience, and membership in a science teacher or science association were identified as factors significantly associated with student science achievement (Table 47). With the exception of nuclear physics, both biology and physics may be viewed as being more concrete experiences for students. Both subjects involve many materials and ideas that most students have encountered prior to formal education in the respective science: plants, animals, algae, fungi, fruit and seeds, reproduction, inheritance of traits, pendulum, simple machines, light, heat, electricity, magnetism, force, energy, and motion. Chemistry introduces concepts that are readily demonstrated in concrete ways such as atoms, molecules, compounds, ions, bonding, London and van der Waals forces, and electron orbitals as wave functions. Being more abstract than the other sciences in question, it may be that chemistry teachers who have studied science as a greater percentage of their postsecondary education, who have had more teaching experience, and who are members of professional associations have a larger repertoire of different methodologies that are effective in presenting abstract chemical concepts. Unfortunately, the SISS questionnaire items did not address the *kind* of teaching experience (for example, within the science discipline and at the level in question), the *kind* of science studied (for example, within the discipline in question), or the level of participation in the professional association (one may be a member but not attend meetings, workshops, conferences). Also, a teacher who is relatively new to teaching or to teaching science, or who has a weak background in the science, or who is not a member of a professional association may work very hard at increasing his or her knowledge of the subject by reading references, working with colleagues who have the content knowledge and/or teaching experience, or by obtaining many of the resources available from professional organizations to anyone who requests them. Thus, a teacher, who on the surface appears not to have a strong background "on paper," may in fact be just as effective as one who has the completed transcript, resume, and membership card.

There were no school factors identified across SISS-U.S. Advanced Science subgroups that were associated with achievement. For the U.S. Advanced Biology subgroup, when the effects of student variables, home background, and teacher variables were controlled, the number of periods in a school day, percent of laboratory use, and the number of female science teachers were found to be significantly and positively associated with student achievement (Table 48).

The number of periods in a school day is related to the length of the school day and the number of minutes in a class period. The relationship is weak and may reflect the small sample size for the SISS-U.S. Advanced Science schools. Assuming a uniform school day for the Advanced Biology schools, a positive association between the number of periods and achievement may be inferred that more class periods but with less time spent in each class. In a review of 34 studies of instructional time and learning measures, Frederick and Walberg (1980) reported a typical correlation between amount of instruction and achievement of about +.40 to +.50. It was noted that in two studies, the logarithm of time was a better predictor than was untransformed time. This was interpreted as suggesting a diminishing return in achievement with ever larger amounts of time. Time use within the class period, i.e., minutes of study or focus on content, was found to be positively related to achievement. Carroll (1961) suggested examining the ratio of time spent to time needed (for learning) to further refine the measure of time to reflect the actual time devoted to the outcome being measured. That higher achievement is associated--albeit weakly--with less time in each class but more classes during the school day may reflect an undetermined limiting factor influencing student attention span and ability to focus actively on class activities.

Table 48

Partial Correlation Coefficients for Significant School Variables Within SISS-U.S. Advanced Science Subgroups

Subgroup	School Variable	Partial Correlation Coefficient	p<
BIOLOGY	Number of periods in a school day	.0903	.05
	Percent of laboratory use for science instruction	.1193	.05
	Number of female science teachers	.0742	.05
CHEMISTRY	Number of male science teachers	.1350	.05
	Class size	.1392	.05

The percent of laboratory use for science instruction is a reflection of school facilities and the support for such facilities by the community. There may be only one or two laboratory rooms for all science courses offered by a school and would result in maximum use for science instruction. A school may have a large number of laboratory rooms dedicated for science instruction, but, due to declining enrollment or a decrease in available funds to support lab work, report a low percent of use for science instruction. Furthermore, if support for science lab work has declined in a school, but enrollment has remained constant or has increased, there may be pressure to utilize "empty" rooms for classrooms for other disciplines thereby reducing the availability of those rooms for science instruction that is not formally presented as a "lab."

The number of female science teachers was identified as a factor positively associated with Advanced Biology achievement (Table 48). The strength of the association is weak, however, and may be a reflection of the small sample size for the school subgroup. In addition, Humrich (1988) found that students of either sex tended to have higher science achievement with male teachers rather than with female teachers.

For the SISS-U.S. Advanced Chemistry subgroup, the number of male science teachers was positively associated with student achievement. This result supports the findings of Humrich (1988) regarding sex and achievement, namely that students who have male science teachers tend to have higher science achievement scores than students who have female science teachers.

Class size was found to be positively associated with U.S. Advanced Chemistry achievement (Table 48). It may be that, with larger classes, there is greater opportunity to share a broader range of ideas and have discussions regarding the more advanced theory presented that would not be possible with smaller classes or with students in an introductory level course. Larger advanced level classes also make it possible to have students work in teams on more complex independent projects in which varieties of skills are required.

It is interesting that there was no school-related variable identified as being positively and significantly associated with U.S. Advanced Physics achievement. [The number of minutes in a class period was negatively associated with Advanced Physics achievement: partial correlation coefficient (controlling for student and teacher variables) was -.1328 at $p < .05$]. It may be that the SISS-U.S. questionnaire items did not adequately address school factors and/or that the results reflect the small sample size of the U.S. Advanced Physics subgroup.

Association of Science Achievement With Student Attitudes and Aspirations

Student science achievement scores were significantly correlated with student attitudes toward science across science subjects (Table 46). Student achievement scores were not significantly correlated with student aspirations for future education and career across science subjects. Partial correlation coefficients (controlling for home background, teacher and school variables) for student science achievement with student aspirations are presented in Table 49. The relatively low coefficients for the SISS-U.S. Advanced Chemistry and Physics subgroups reflects the homogeneity of these groups compared with the Advanced Biology subgroup regarding aspirations for future education and career (see Table 16, page 74, and Table 17, page 75).

Table 49

Partial Correlation Coefficients for SISS-U.S. Advanced Science Student Achievement With Student Aspirations

Advanced Science Subgroup	Partial Correlation Coefficient
Biology	.2290**
Chemistry	.0521
Physics	.0920*

*Significant at $p < .05$
**Significant at $p < .001$

Association of Science Achievement With Time Spent on Science Homework

Across science subjects, the amount of time spent on science homework was not significantly correlated with student achievement when the effects of home background and teacher and school variables were partialed out. The Pearson product-moment coefficients for the association of science achievement with time spent on science homework are presented in Table 50. As shown earlier (Table 20, page 77), the majority of students in each of the three subgroups reported spending about the same amount of time on science homework: up to two hours per week.

Table 50

Pearson Product-Moment Coefficients for SISS-U.S. Advanced Science Student Achievement With Time Spent on Science Homework

Advanced Science Subgroup	Pearson Product-Moment Coefficient
Biology	.1396**
Chemistry	.1715**
Physics	.1119*

*Significant at $p < .05$ **Significant at $p < .001$

Association of Science Achievement With Specified Teacher Variables

The correlation of student science achievement with teacher variables of preparation in science, reading of education and science journals, participation in inservice programs, and membership in science teacher or science associations was not positive nor significant across SISS-U.S. Advanced Science subgroups. Partial correlation coefficients (controlling for the effects of student and school variables) for student achievement with each of the above teacher variables are presented in Table 51.

The results of the correlational analyses--most coefficients are negative and only one is both positive and significant--are contrary to the findings in other studies (Comber and Keeves, 1973; Keys, 1987). These results may well be an artifact of the small sample size for the SISS-U.S. Advanced Science teacher population as well as the impact of the design effect on the sample sizes of both students and teachers.

Table 51

Partial Correlation Coefficients for SISS-U.S. Advanced Science Student Achievement With Specified Teacher Variables

Teacher Variable	Advanced Science Subgroup	Partial Correlation Coefficient
Preparation in Science	Biology	- .0387
	Chemistry	- .0152
	Physics	- .0702
Reading Science Journals	Biology	- .0249
	Chemistry	- .0008
	Physics	- .0878
Reading Education Journals	Biology	- .0696
	Chemistry	- .0263
	Physics	+.0003

(table continues)

Teacher Variable	Advanced Science Subgroup	Partial Correlation Coefficient
Participation in Inservice Programs	Biology	- .0588
	Chemistry	+ .0790
	Physics	- .0196
Membership in Science Teacher/Science Assn.	Biology	- .0957
	Chemistry	+ .1466*
	Physics	- .0928

*Significant at $p < .05$

Association of Science Achievement With Minimum Years of Science and Mathematics Required For Graduation from High School

Across subjects, SISS-U.S. Advanced Science student science achievement was not found to be positively and significantly correlated with the minimum years of science required for graduation from high school. Only Advanced Biology achievement was positively and significantly correlated with the minimum years of mathematics required for graduation from high school. The Pearson product-moment coefficients for these school variables with Advanced Science achievement are presented in Table 52. These results are not meaningful to this researcher since, on average, the SISS-U.S. Advanced Science students reported having studied more years of either mathematics or science than the average required.

Table 52

Pearson Product-Moment Coefficients for SISS-U.S. Advanced Science Student Achievement With Minimum Years of Science and Mathematics Required for Graduation From High School

School Factor	Subgroup	Pearson Product-Moment Coefficient
Minimum Years of Science		
	Biology	+ .0137
	Chemistry	- .1078*
	Physics	- .0446
Minimum Years of Mathematics		
	Biology	+ .2170**
	Chemistry	- .1504**
	Physics	- .1451*

*Significant at $p < .05$
**Significant at $p < .001$

Association of Science Achievement With Class Size

SISS-U.S. Advanced Science achievement in chemistry was positively and significantly associated with class size. The correlation with Advanced Biology achievement was negative and significant; with Advanced Physics achievement, the association was positive and nonsignificant. Given the limited data set for each of the SISS-U.S. Advanced Science subgroups, substantive correlations were not expected. Partial correlation coefficients (controlling for student and teacher variables, and for school location and area population) are presented in Table 53.

Table 53

Partial Correlation Coefficients for SISS-U.S. Advanced Science Achievement With Class Size

Subgroup	Number of Classes	Mean Class Size	SD	Partial Correlation Coefficient
Biology	43	18.0	5.8	- .1038*
Chemistry	37	18.4	8.8	+ .1392*
Physics	34	18.9	6.9	+ .0673

*Significant at $p < .05$

Association of Science Achievement With the Amount of Physical Science Studied Relative to the Amount of Biological Science Studied

SISS-U.S. Advanced Biology students who reported having studied more physical science than biological science had significantly higher achievement scores on the SISS science test than those of student who reported having studied more biological science than physical science. Results of *t*-tests on the equality of mean science scores between the two groups of Advanced Biology students are presented in Table 54.

Meaningful comparisons of students in the SISS-U.S. Advanced Chemistry and Physics subgroups were not possible due to the high degree of homogeneity among the students regarding science background. In the chemistry subgroup, 421 of 562 students reported having studied more physical science than biological science while 24 students reported having studied more biological science than physical science. In the physics subgroup, 432 of the 500 SISS-U.S. Advanced Physics students reported having studied more physical science than biological science while eight students reported having studied more biological science than physical science.

The implication of these results for biology achievement is that the study of physical science, e.g., chemistry, physics, and earth science, contribute to a better understanding of processes involving and occurring in living organisms. When the nature of the recent advances in biology are considered, such as genetic engineering, biochemical and biophysical assays of neural functions and of the immune system, the separation of the biological and physical sciences becomes unrecognizable. A review of the life science and biology texts used in schools would demonstrate that the "chemistry of living things" is presented not only at the advanced levels of study, but also at the introductory high school--and junior high school--levels.

Table 54

SISS-U.S. Advanced Biology: Comparison of Achievement Scores Associated With the Amount of Physical Science Studied Relative to the Amount of Biological Science Studied*

Student Science Background	N	Mean Score	SD	% Correct
Studied more physical science than biological science	148	11.5 **	4.4	46.0
Studied less physical science than biological science	286	8.8	3.7	35.2

* Scores based on 25 international items
** Significant at $p < .001$

Association of Science Achievement With the Evaluation of Homework by Teachers

Across science subjects, Advanced Science students whose teachers frequently or often evaluated homework had achievement scores that were not significantly different than those of students whose teachers did not frequently or often evaluate homework. Previous studies (Berliner, 1985; Elawar and Corno, 1985; Walberg, 1985) involved students and teachers in the elementary grades through high school, but none involved students in advanced academic courses. It is possible that evaluation of homework is a significant factor for achievement in introductory level courses, but is less important for advanced levels--particularly those courses in which the students are self-selected such as the advanced level sciences.

Regression Analyses

Based on the correlational analyses and subsequent *t*-tests, student, teacher, and school variables that had been identified as being associated with SISS-U.S. Advanced Science student achievement were analyzed to determine estimates of their contribution to student achievement.

Composite variables were formed for the individual student, teacher, and school variables in order to decrease the multicollinearity within the variable sets. Furthermore, there were more teacher variables than there were data points for the teachers as well as intercorrelations among the teacher variables.

In accordance with the IEA Memorandum 121 (1984), variables were selected for inclusion in the multiple regression analyses on the basis of positive and significant correlation with the criterion variable, i.e., the student scores on the SISS achievement tests. By using partial correlation coefficients, controlling for all other sets of variables, a relatively small set of variables was obtained for each SISS-U.S. Advanced Science subgroup. Where two or more individual variables had high intercorrelations, composite variables were formed to reduce the degree of multicollinearity among the final variables. An additional consideration was a theoretical basis for inclusion in analyses based on prior research findings.

Although being in an Advanced Placement (AP) science course was not among the variables originally selected in the hypotheses, AP emerged as a candidate variable for the regression analyses. T-tests were done on each of the SISS-U.S. Advanced Science subgroups regarding the equality of the mean scores of students in AP science compared with students in non-AP science. Across the science subgroups, students in AP courses had significantly higher ($p < .001$) science achievement scores than did students in non-AP courses regardless of the grade level of the students. The partial correlation coefficients (controlling for student background and home variables) for SISS-U.S. Advanced Science achievement with being in an AP science course are presented in Table 55. Comparisons of achievement scores of AP students with those of non-AP for each of the SISS-U.S. Advanced Science subgroups ar presented in Table 56.

Table 55

Partial Correlation Coefficients for SISS-U.S. Advanced Science Achievement With Taking Advanced Placement Science by Subgroup

Subgroup	Partial Correlation Coefficient
Biology	.1389 *
Chemistry	.2868 *
Physics	.1807 *

* Significant at p < .001

Table 56

Comparison of Science Achievement Scores of Advanced Placement Students with Non-Advanced Placement Students by SISS-U.S. Advanced Science Subgroup (Based on International Common Items)

Advanced Science Subgroup	N	Mean Score	SD	Mean % Correct
BIOLOGY				
Advanced Placement	102	12.4*	5.2	49.6
Non-Advanced Placement	572	9.4	4.0	37.6
CHEMISTRY				
Advanced Placement	117	11.7*	5.9	46.9
Non-Advanced Placement	445	7.9	4.1	31.7
PHYSICS				
Advanced Placement	280	12.3*	4.7	47.3
Non-Advanced Placement	220	10.3	3.9	39.6

* Difference in scores is significant at p < .001.

As shown in Table 56, across science subjects, the AP science students had significantly higher scores than the non-AP science students. When grade level of student, years of mathematics studied, and years of science studied were controlled, the AP science students in all three subgroups had significantly higher achievement scores compared with non-AP students. In fact, across the U.S. Advanced Science subgroups, the AP students who had studied *at least 3 years each of mathematics and science* had science achievement scores that were *NOT* significantly different from the international mean score for the respective tests.

The composite variables that were developed for all three SISS-U.S. Advanced Science variable sets are presented in Table 57. Questionnaire and opinionnaire item numbers are indicated in parentheses. Composites were formed by summing across the values of the individual variables. For those individual variables that had intervals for categories, the midpoint of each interval was used in calculations.

Table 57

Composite Variables Developed for Regression Analyses

Composite Variable Name	Composition of Variable
STUDENT COMPOSITES	
HOME	Father education/occupation Mother education/occupation Number of books in home Q12 - Q16
ABILITY	Student scores on SISS Mathematics and Word Knowledge Tests
SCIATT	Science Attitudes: A03, A05, A07, A08, A09, A10, A13, A15, A17, A18, A19, A24, A25, A26, A27
SCINTRST	Science Interest: A01, A04, A11, A16, A22, A23, A28, D09
ASPIRAT	Aspirations for Education and Career; Q02, Q03
PHYSCI	Number of full years of physical science studied, grades 9-12; obtained from Student Science Course History

(table continues)

Composite Variable Name	Composition of Variable
SCI	Total number of full years of science studied, grades 9-12
AP	Advanced Placement class; obtained from RTI background file
YRSMATH	Years of Math Studied; Q08
TEACHER COMPOSITES	
TSEX	Sex; Teacher Questionnaire Item
TEXP	Teaching Experience; TQ04
TPOSTED	Postsecondary Education; TQ02
TPOSTSCI	Postsecondary Science Study; TQ03
SCIASSN	Membership in science association; TQ12
TEXT	Importance placed on prescribed text (recoded: little importance had high value); TQ24
EXTEXAM	Importance of external exam students must take; TQ25
LECTURE	Frequency of lecture; TQ31
TESSAY	Frequency use of teacher-made essay test; TQ41
EVALLAB	Evaluate lab work; TQ44
EVALHMWK	Evaluate homework; TQ43
STDTEST	Frequency of using standardized tests; TQ40
SCHOOL COMPOSITES	
NPER	Number of periods per day; AQ04
LABUSE	Percent lab use; AQ11
SCITCHM	Number of male science teachers; from School Questionnaire

SISS-U.S. Advanced Biology: Regression Analyses

The regression of biology achievement on the student, teacher, and school variables resulted in approximately 40% of the variance in student achievement explained. The set of variables that gave the largest R^2 value included: ABILITY, HOME, SCIATT, SCINTRST, YRSMATH, PHYSCI, AP, TEXT, EVALHMWK, EVALLAB, LECTURE, NPER, and LABUSE. All variables were analyzed using SPSS^{X} REGRESSION with forced entry of variables and mean substitution. The summary table for the final equation is presented in Table 58.

From the data in Table 58, when SISS-U.S. Advanced Biology student achievement is regressed on the student, teacher, and school variables, ability of the student appears to be the best predictor of achievement from among the variables in this study. Additional variables that appear to contribute most to student achievement are the student's attitude toward science, interest in science, and taking Advanced Placement Biology.

Table 58

Summary of Regression Analysis for SISS-U.S. Advanced Biology Student Science Achievement

Variable	B	SE B	Beta	MultR	R^2	R^2 Change
ABILITY	.2873	.0224	.4702	.5772	.3331	.3331
HOME	.0007	.0008	.0276	.5815	.3381	.0050
SCIATT	.0531	.0343	.0569	.5906	.3488	.0108
SCINTRST	.1397	.0394	.1257	.6014	.3617	.0128
YRSMATH	.1090	.1829	.0229	.6056	.3668	.0051
PHYSCI	.1076	.1482	.0276	.6063	.3676	.0008
AP	1.1466	.3962	.0954	.6149	.3781	.0105
TEXT	.3977	.2066	.0654	.6164	.3799	.0018
EVALHMWK	.2033	.1085	.0611	.6197	.3841	.0042
EVALLAB	.3851	.2157	.0576	.6210	.3857	.0016
LECTURE	.2989	.1444	.0664	.6242	.3896	.0039
NPER	.0373	.0255	.0482	.6254	.3911	.0015
LABUSE	.0178	.0090	.0625	.6283	.3947	.0036
(constant)	-10.2664	1.8469				

SISS-U.S. Advanced Chemistry: Regression Analyses

The regression of chemistry achievement on the student, teacher, and school variables resulted in approximately 40% of the variance in student achievement explained. The composite variables that resulted in the largest value for R^2 in the regression equation were: HOME, ABILITY; SCIATT; SCINTRST; AP; TPOSTED; TEXP; SCIASSN; TEXT; and SCITCHM. All variables were analyzed using $SPSS^X$ REGRESSION with forced entry of variables and mean substitution. A summary table for the final equation is given in Table 59.

From the data presented in Table 59, a student's ability appears to be the best predictor of SISS-U.S. Advanced Chemistry achievement for this sample. The second best predictor of achievement is taking Advanced Placement Chemistry. Additional variables that contributed the most to student achievement for this sample were the amount of postsecondary education of the teacher, the teacher perceiving the prescribed textbook as being of little importance in determining what is to be taught, and the teacher's teaching experience.

Table 59

Summary of Regression Analysis for SISS-U.S. Advanced Chemistry Student Science Achievement

Variable	B	SE B	Beta	MultR	R^2	R^2 Change
HOME	-.0015	.0009	-.0573	.1056	.0111	.0111
ABILITY	.3023	.0276	.4038	.5066	.2567	.2455
SCIATT	.0802	.0409	.0722	.5111	.2612	.0046
SCINTRST	.0862	.0487	.0639	.5180	.2683	.0071
AP	1.9311	.4504	.1678	.5781	.3342	.0658
TPOSTED	.5691	.1678	.1238	.5996	.3595	.0253
TEXP	.0688	.0254	.1017	.6148	.3780	.0185
SCIASSN	-.6997	.3703	.0276	.6184	.3825	.0044
TEXT	1.5835	.3404	.1639	.6355	.4038	.0214
SCITCHM	.0115	.0065	.0714	.6381	.4072	.0034
(Constant)	-13.2484	1.83053				

SISS-U.S. Advanced Physics: Regression Analyses

The regression of physics achievement on the student, teacher, and school variables resulted in approximately 28% of the variance in student achievement explained. The composite variables that resulted in the largest value for R^2 in the regression equation were: ABILITY, HOME, YRSMATH, SCI, PHYSCI, AP, SCINTRST, EXTEXAM, and STDTEST. All variables were analyzed using SPSS^X REGRESSION with forced entry of variables and mean substitution. A summary table for the final equation is given in Table 60.

From the data presented, the best predictor of SISS-U.S. Advanced Physics student achievement appears to be student ability. The second best predictor of student achievement for this sample is taking Advanced Placement Physics followed by the total number of years of science studied, grades 9-12. An additional variable that appears to be a good predictor of student achievement is the frequency of the teacher using standardized tests.

Table 60

Summary of Regression Analysis for SISS-U.S. Advanced Physics Student Science Achievement

Variable	B	SE B	Beta	MultR	R^2	R^2 Change
ABILITY	.2092	.0308	.2788	.3968	.1575	.1575
HOME	.0024	.0009	.0978	.4139	.1713	.0138
SCINTRST	.1049	.0551	.0754	.4193	.1758	.0045
YRSMATH	.8660	.2996	.1156	.4340	.1884	.0125
SCI	-.1602	.1659	-.0596	.4628	.2142	.0258
PHYSCI	.6384	.1966	.1983	.4772	.2277	.0135
AP	1.6007	.3726	.1712	.5036	.2536	.0259
EXTEXAM	.3369	.1383	.0987	.5094	.2595	.0059
STDTEST	.5637	.1456	.1564	.5305	.2815	.0220
(constant)	-8.3929	1.9812				

Summary

In this Chapter, tests of stated hypotheses were presented. Student, teacher, and school variables associated with SISS-U.S. Advanced Science student achievement were identified. Results of regression analyses for SISS-U.S. Advanced Science student achievement on identified student, teacher, and school variables were presented.

The major findings of the analyses of the SISS-U.S. Advanced Science student achievement include:

1. Each SISS-U.S. Advanced Science subgroup had a mean score on the respective SISS science test significantly below the international mean for that test.
2. Across science subjects, SISS-U.S. Advanced Science student achievement scores on the SISS Mathematics Test were positively and significantly correlated with student scores on the SISS Advanced Science Test.
3. Across science subjects, SISS-U.S. Advanced Science student achievement scores on the SISS Word Knowledge Test were positively and significantly correlated with student scores on the SISS Advanced Science Test.
4. Four student factors associated with SISS-U.S. Advanced Science achievement were identified as being common to all subgroups:
    a. Ability; determined by student scores on the SISS Mathematics and Word Knowledge Tests;
    b. Amount of physical science studied, grades 9-12; determined by student responses to questions regarding science course history, grades 9-12;
    c. Interest in science; determined by student responses to opinionnaire items;
    d. Attitude toward science; determined by student responses to opinionnaire items.
5. Across science subgroups, the best predictor of SISS-U.S. Advanced Science student achievement was student ability as determined by the student scores on the SISS Mathematics and Word Knowledge Tests.
6. Additional predictor variables for the SISS-U.S. Advanced Biology subgroup were student attitude toward science, student interest in science, and taking Advanced Placement Biology.

7. Additional predictor variables for the SISS-U.S. Advanced Chemistry subgroup were taking Advanced Placement Chemistry, the postsecondary education of the science teacher, the teacher perceiving the prescribed textbook as being of "little importance" in determining curriculum, and the teacher's teaching experience.
8. Additional predictor variables for the SISS-U.S. Advanced Physics subgroup were taking Advanced Placement Physics, the total number of years of science studied, and the frequency of the science teacher using standardized tests.
9. On average, SISS-U.S. Advanced Science students who were taking an Advanced Placement science course had significantly higher science achievement scores than did students who were in non-Advanced Placement science courses.
10. No teacher variables associated with SISS-U.S. Advanced Science achievement common to all three subgroups were identified. For the SISS-U.S. Advanced Biology subgroup, the identified teacher variables were:
    a. Perceived importance of the prescribed textbook in determining curriculum; the questionnaire item had been recoded so that "little importance" received a high value while "very important" received a low value;
    b. Frequent use of teacher-made essay tests;
    c. Use of performance on homework to assess student work;
    d. Use of performance on lab/project to assess student work;
    e. Frequent use of lecture.

    The identified teacher variables for the SISS-U.S. Advanced Chemistry subgroup were:
    a. Postsecondary study of science;
    b. Membership in science teacher or science association;
    c. Perceived importance of prescribed textbook in determining curriculum;
    d. Frequent use of teacher-made essay tests;
    e. Use of performance on lab/project to assess student work.

    The identified teacher variable for the SISS-U.S. Advanced Physics subgroup was: Perceived importance of an external exam that students must take in determining curriculum.

11. There were no school variables associated with SISS-U.S. Advanced Science achievement common to all three subgroups. The identified school factors for the SISS-U.S. Advanced Biology subgroup were:
    a. Number of periods in a school day;
    b. Percent of laboratory use for science instruction;
    c. Number of female science teachers.

    The school factors associated with SISS-U.S. Advanced Chemistry achievement were identified as:
    a. Number of male science teachers;
    b. Class size.

    There were no school factors identified as being associated with SISS-U.S. Advanced Physics students achievement.
12. Across science subgroups, SISS-U.S. Advanced Science student achievement was positively and significantly correlated with student attitudes toward science.
13. Across science subgroups, SISS-U.S. Advanced Science student achievement scores were not significantly correlated with student aspirations for future education and career. When home background, teacher, and school variables were controlled, the correlation was significant only for the SISS-U.S. Advanced Biology and Physics subgroups. The strength of the association between student aspirations and science achievement was stronger for the Biology subgroup than for the Physics subgroup.
14. Across science subgroups, the amount of time spent on science homework was not significantly correlated with student achievement when the effects of home background, teacher, and school variables were partialed out. Zero-order Pearson product-moment coefficients were positive and significant ($p < .001$ for Biology and Chemistry; $p < .05$ for Physics) for all three SISS-U.S. Advanced Science subgroups.
15. Membership in a science teacher or science association was positively and significantly correlated with SISS-U.S. Advanced Chemistry student achievement only. With two other exceptions (reading of general education journals for the Physics teachers, and participation in inservice programs for the Chemistry teachers), the specified teacher variables of preparation in science, reading science journals, reading general education journals, participation in inservice programs, and

membership in science teacher or science association were negatively correlated with SISS-U.S. Advanced Science student achievement when the effects of home background, student, and school variables were partialed out.

16. The minimum number of years of science required for graduation from high school was not positively and significantly correlated with SISS-U.S. Advanced Science student achievement. The minimum number of years of mathematics required for graduation from high school was positively and significantly correlated with SISS-U.S. Advanced Biology student achievement only.
17. Class size was found to be positively and significantly correlated with SISS-U.S. Advanced Chemistry student achievement. The association of SISS-U.S. Advanced Science student achievement with class size was negative for Advanced Biology, positive and significant for Advanced Chemistry, positive and nonsignifcant for Advanced Physics.
18. SISS-U.S. Advanced Biology students who reported having studied more physical science than biological science had significantly higher scores on the SISS Advanced Biology Test than did students who reported having studied more biological science than physical science. The degree of homogeneity within the SISS-U.S. Advanced Chemistry and Physics subgroups regarding the amount of physical science studied was such that no meaningful comparisons could be made for these subgroups.
19. Across science subgroups, SISS-U.S. Advanced Science students whose teachers reported frequently or often evaluating homework did not have significantly higher achievement scores compared with students whose teachers reported not evaluating homework frequently or often.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

In this Chapter, the study is summarized, conclusions are drawn from significant findings, and recommendations for future research are presented. No attempt is made in this Chapter to comprehensively reiterate material presented in the previous Chapter. For greater detail on specific results of this study, the reader is referred to Chapter IV.

Summary

The Second International Science Study (SISS) was conducted within the purposes and structure of the "Second International Association for the Evaluation of Educational Achievement Study." This global project was one of the largest international studies in education to date. The science part of this Study, one of six areas studied, is known as the "Second IEA Science Study" or as "SISS."

The Second IEA Science Study was begun in 1980 and was patterned after its predecessor, the First IEA Science Study (FISS). FISS was conducted between 1966 and 1971 and has been described in *Science Education in Nineteen Countries* (Comber and Keeves, 1973).

The primary importance of the SISS is its international scope. The major intent of the SISS has been to allow comparisons within and across national educational systems. Some countries, such as the United States, have chosen to conduct studies specific to internal policies for local analyses in addition to the international comparative studies and in so doing made optional changes in the SISS instruments.

The major problem for this study was to determine the level of achievement of United States Advanced Science students within the context of the Second IEA Science Study. A second purpose was to identify those teacher and school factors which are associated with the science achievement of SISS-U.S. Advanced Science students. Eleven hypotheses pertaining to student achievement and related factors were investigated and tested.

The present study focused on students in SISS Population 3: students in the last years of precollege secondary school. SISS Populations 3B, 3C, and 3P consisted of students studying biology, chemistry, and physics, respectively. In the United States, these populations were expanded to include ALL students studying a *second-year* (advanced level) science course in biology, chemistry, or physics.

In all participating countries, questionnaire information was obtained from students, teachers, and school administrators. Data obtained included information about student family and science background, attitudes toward and interests in science, teacher background, and school characteristics such as location and facilities.

The United States sample was designed by Research Triangle Institute, Research Triangle, NC. The present study was a three-stage probability design: counties containing two or more high schools which offered the advanced science course(s); the unique schools within the selected counties; and the intact classes within the selected schools. Counties were chosen with a probability-proportional-to-size from the four national Census geographic regions. The schools were stratified by public and private status, being in a metropolitan or nonmetropolitan region, and geographic area.

The design involved sampling over 700 public and private secondary schools in the United States which offered at least one Advanced Science course. Intact classes were chosen, at random wherever possible, to participate. Responses to structured questionnaires were received from more than 1700 students, 117 teachers, and 115 school administrators. Advanced Science achievement tests in biology, chemistry, and physics were administered to students in the appropriate classes. Students were also given a Mathematics Test and a Word Knowledge Test appropriate for the level of science.

Analyses of the data were conducted using a standard statistical package: SPSS^X. Much of the analyses consisted of descriptive statistics. The impact of the design effect was described. No inferences about causal relationships were made.

No generalizations are intended beyond those that can be stated relative to the student, teacher, and school administrator respondents from the sample.

The most significant findings of the data analyses of the SISS-U.S. Advanced Science student achievement on the SISS tests include:

1. Each SISS-U.S. Advanced Science subgroup had a mean score that was significantly below the international mean for the respective test.
2. Across science subjects, the best predictor for SISS-U.S. Advanced Science student achievement was student ability as determined by scores on the SISS Mathematics and Word Knowledge Tests.
3. SISS-U.S. Advanced Science students who were taking an Advanced Placement (AP) science had significantly higher science achievement scores than students who were in non-Advanced Placement science courses. SISS-U.S. Advanced Science AP students who reported having studied at least three years each of mathematics and science had science achievement scores that were not significantly different from the international mean scores for the respective tests.
4. In addition to ability, three other student factors associated with science achievement were common to the three SISS-U.S. Advanced Science subgroups: amount of physical science studied, interest in science, and attitude toward science. The amount of physical science studied was most significant for the SISS-U.S. Advanced Biology subgroup.
5. The minimum numbers of years of mathematics or science required for graduation from high school were not significantly correlated with SISS-U.S. Advanced Science student achievement.
6. Across science subgroups, time spent on science homework was not significantly associated with SISS-U.S. Advanced Science student achievement.
7. Across science subgroups, student aspirations for future education and career were not significantly correlated with SISS-U.S. Advanced Science achievement.

Conclusions

Results from cross-national comparative studies in education may be misleading unless efforts are made to have truly comparable samples.

Aggregated data permit only gross comparisons to be made. Disaggregated data allow more information to be made available for analysis and therefore provide a broader basis upon which to draw conclusions and/or inferences.

In the aggregated data, there is no indication of the diversity of students within the SISS-U.S. Advanced Science samples relative to grade level, science and mathematics background, or advanced science course discrimination regarding Advanced Placement designation. It is inaccurate to state simply that the SISS-U.S. Advanced Science students scored among the lowest four participating countries based on the findings of this study regarding the achievement of the Advanced Placement students. However, the number of students in the AP-designated science courses is small compared with the total number of SISS-Advanced Science students: approximately 28% of the students in the total SISS-U.S. sample were in Advanced Placement courses.

It is disturbing that the achievement scores of the SISS-U.S. Advanced Science students as determined by the SISS instruments are among the lowest of the SISS participants. Typically, the advanced level courses attract students who are in the "pipeline" for engineering and science careers--these students *choose* to take the advanced level science courses--and yet the overall science achievement level of the SISS-U.S. Advanced Science students was disappointingly low.

It was not surprising to find that student ability contributes the most and is the best predictor of science achievement at the advanced level. It was interesting to note that the influence of home background, generally understood as being so important in earlier grades and with younger students, was not a primary factor in predicting advanced science student achievement or in being among major contributors to advanced science achievement.

That student attitudes toward and interest in science are contributors to science achievement is significant since these are areas in which teachers and schools can make a difference in how science is presented--and how the student perceives science--beginning in the primary grades and continuing through the university years.

That so few teacher and school factors emerged as being contributors to and predictors of science achievement reflects in part the relatively small sample size of the teacher/school population. Also, the Questionnaires for the teachers and school administrators did not elicit enough information about what goes on in the science classroom and in the school. For example, there were items concerning access to computers for use in science instruction and the frequency of using a computer during science lessons by either the teacher or students. However, the concept of "frequently" is subjective at best. Also, exactly what is done with a computer during science lessons? Is the computer used for remedial drill/practice? or is it used for interfacing with thermistors and probes? How many computers are available for use during science lessons? Are they readily available or must the teacher plan ahead to reserve a computer? These kinds of questions were not asked on the SISS instruments. In order to obtain such detailed information would involve a greater time commitment on the part of the teacher and of the school administrator in completing a longer questionnaire.

There were additional teacher items concerning the use of small groups, doing demonstrations, having students do laboratory experiments, using audiovisual materials, and using question-and-answer methods. Responses were limited to frequency of use--not HOW things were used. Students often work in pairs in science labs because of limited materials. Does working in pairs mean the same as working in cooperative teams? What is a laboratory "experiment?" Is a lab book used to direct lab activities? Are the "experiments" open-ended or "cook book" style? What audiovisual materials are used? Overhead projectors? Slide projectors? Video tapes? For what purposes are such materials used? To record potentially dangerous demonstrations for playback to the class? To have a clear unobstructed view of a demonstration? To reinforce or preview work? What kinds of questions are asked of the students? Are they quick-answer or do they require thought and several complete sentences for a coherent response? These are the kinds of questions that have been raised during this study.

To this researcher, the findings of the study concerning teacher and school factors related to student achievement are disappointing. Teaching and learning are too complex to study by using "yes/no," "frequently/often/rarely/never" kinds of responses that are self-reported.

Many of the school questionnaire responses were proxies for the socioeconomic status of the community; for example, monies spent on supplies, texts, equipment, field trips. The number of rooms dedicated for science instruction is related to the physical size of the school and the funds available to convert "extra" classrooms to lab facilities. Also, a school may have several "lab rooms" or one, but there were no items on either the teacher or school questionnaire regarding the degree to which the labs were equipped with equipment that is adequate in quantity and quality for the students using it.

There were several school questions about the number of minutes per period, number of periods per day, number of hours in a school week, and number of weeks in a school year. But the question of "How many minutes per five day week are allocated for science instruction for the class being tested?" was not asked. Some schools have such tight schedules that science classes--even the "advanced" levels--meet only one 40-45 minute period a day. Other schools may have an "extra" class period for labs once a week. Still other schools may schedule "double-periods" for labs twice a week, or in some cases, every other day, so that a class may meet seven periods one week and eight periods the next. Such variations in the amount of time allocated for science instruction can affect what is taught, how it is taught, and how much is taught.

In summary, it may be concluded that

1. On average, SISS-U.S. Advanced Science students did not demonstrate acceptable levels of science achievement as determined by the SISS tests;
2. Students who plan on studying science at advanced levels would have higher overall science achievement if they study more physical science than biological science prior to taking advanced science; this appears to be more significant for students studying advanced biology than chemistry or physics;
3. Advanced science teachers can contribute to their students' achievement by not placing very much importance on a prescribed textbook in determining what is to be taught, by using teacher-made essay tests, and by evaluating labs/projects in assessing student work;
4. Teachers and schools can contribute to students' achievement in advanced science by fostering positive attitudes toward science and encouraging student interest in science.

Recommendations

Recommendations for improvement in Advanced Science instruction and for additional research are made on the basis of the findings of this study.

For improvement in Advanced Science instruction:

1. Early introduction of students to science as an enjoyable, interesting process;
2. Support for science instruction/science education be made overtly by the school and community so that students may be encouraged to pursue further science study and careers;
3. Inclusion of more physical science in school science programs;
4. Acknowledgement by school administrators, as well as the community, that improvements in educational systems take time, that immediate results are rarely observed; and that program changes should start at the bottom, i.e., in the primary and elementary grades, in order to build a foundation for positive attitudes and interests in science.

For further research on Advanced Science student achievement:

1. Repetition of the SISS-U.S. study with larger student, teacher, and school sample sizes; studies should disaggregate data to identify subgroups of students and discriminating factors;
2. Future questionnaires be designed to obtain more quantifiable responses; for example, use "once a week," "twice a week," rather than "frequently" or "often;"
3. Longitudinal studies to be carried out within individual school district/schools to assess science programs and student outcomes; also these studies can be used to "track" students through precollege science/mathematics programs with follow-up of students after graduation from high school.

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APPENDIX A

SISS-U.S. ADVANCED SCIENCE COURSE OFFERINGS

Listed are the course titles as given by the SISS-U.S. Advanced Science school administrators for the classes that were tested by Advanced Science subgroup.

ADVANCED BIOLOGY:	Advanced Biology
	Advanced Placement Biology
	Anatomy and Physiology
	Biology II or Biology 2
	Botany
	Genetics
	Physiology
ADVANCED CHEMISTRY:	Advanced Placement Chemistry
	Advanced Chemistry
	Chemistry II or Chemistry 2
	Organic Chemistry
ADVANCED PHYSICS:	Advanced Placement Physics
	Advanced Physics
	Physics II or Physics 2

APPENDIX B

SISS-U.S. Advanced Science Student Booklet 2: Mathematics Test; Student Questionnaire; Student Opinionnaire; Student Description of Science Learning; and Word Knowledge Test

International Science Study

Advanced Science

Booklet 2

Supported by
National Science Foundation

Conducted by
Columbia University
Research Triangle Institute

The Second International Science Study is being conducted with the support of the National Science Foundation. While you are not required to respond, your cooperation is needed to make the results of this study comprehensive, accurate, and timely. All information that would permit identification of an individual, a school, or a school district will be held in strict confidence.

INSTRUCTIONS

This booklet has six sections. The first section is a mathematics test. Each of the questions is followed by five suggested answers, shown by the letters A, B, C, D, and E. For each question you must choose the one answer you think is correct. In the section of the Answer Sheet headed MATHEMATICS TEST-BOOKLET 2, darken the circle for the appropriate letter.

If you do not know the answer to a question, leave it and go on to the next question. You can come back to the question later. You may answer questions even if you are not sure of the answer, but do not guess blindly.

You will have 10 minutes to complete this section of the booklet. When you have completed the mathematics test, please do not continue until told to do so by the test administrator.

Please do not begin until you are told to do so.

1 There are 227 students in a school. Every student in the school belongs to either the music club or the sports club, and some students belong to both clubs. The music club has 120 members, and 36 of these are also members of the sports club. What is the total membership of the sports club?

A 84

B 107

C 120

D 143

E 191

2 The expression $6 \times 10^5 + 2 \times 10^4 + 7 \times 10^3 + 9$ is equal to

A 6,279

B 62,709

C 602,709

D 627,009

E 6,020,709

3 $\frac{a}{15} - \frac{b}{5}$ is equal to

A $\frac{a - 3b}{15}$

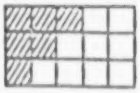
B $\frac{5a - 15b}{15}$

C $\frac{a - b}{10}$

D $\frac{a - b}{75}$

E $\frac{3a - 5b}{75}$

4



In the figure the little squares are all the same size, and the area of the whole rectangle is equal to 1.

The area of the shaded part is equal to

A $\frac{2}{15}$

B $\frac{1}{3}$

C $\frac{2}{5}$

D $\frac{3}{8}$

E $\frac{1}{2}$

5 Frank decided to make a bar graph to show the maximum temperature on four days. He made this table to help him draw the graph.

Day	Mon	Tue	Wed	Thur
Maximum temperature	16 °C	18 °C	21 °C	24 °C
Height of bar	8 cm	9 cm		12 cm

What should be the height of the bar for Wednesday?

A 9.5 cm

B 10 cm

C 10.5 cm

D 21 cm

E 42 cm

6 If $\frac{2}{\Delta} = \frac{\Delta}{8}$, then Δ can be equal to

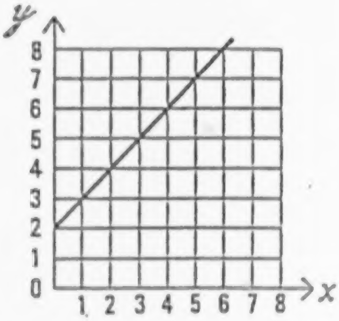
A 1

B 2

C 4

D 8

E 16



7 The equation of the graph shown above is

A $y = x + 1$

B $y = x + 2$

C $y = 2x + 1$

D $y = 2x + 2$

E $y = 3x - 2$

8 A solid plastic cube with edges 1 centimeter long weighs 1 gram. How much will a solid cube of the same plastic weigh if each edge is 2 centimeters long?

A 16 grams

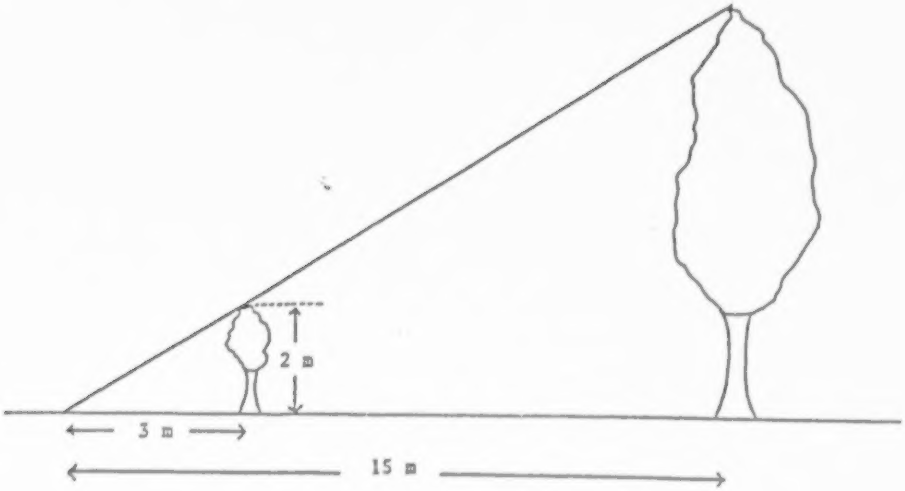
B 8 grams

C 4 grams

D 3 grams

E 2 grams

9



The picture above shows a method of finding the height of a tall tree using a short tree. What is the height of the tall tree?

A 8 meters

B 10 meters

C 15 meters

D 18 meters

E 20 meters

10 If $\frac{x}{2} < 7$, then

A $x < \frac{7}{2}$

B $x < 5$

C $x < 14$

D $x > 5$

E $x > 14$

11 A factory produces m cars per week. How many cars per week will it produce after production is increased p per cent?

A $100p + m$

B $100m + mp$

C $\frac{m + mp}{100}$

D $m + \frac{mp}{100}$

E $\frac{p}{100} + m$

12 If $xy = 1$ and x is greater than 0, which of the following statements is true?

A When x is greater than 1, y is negative.

B When x is greater than 1, y is greater than 1.

C When x is less than 1, y is less than 1.

D As x increases, y increases.

E As x increases, y decreases.

13 A certain operation written as ∇ is defined by:

$a \nabla b = \frac{b - a}{a}$ for any numbers a and b.

If $5 \nabla b = \frac{2}{5}$, what is the value of b?

A 2

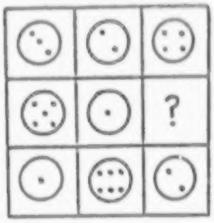
B 3

C 5

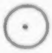
D 7

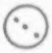
E 9

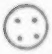
14

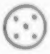


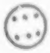
Part of the pattern above is missing as shown by the question mark. Which figure best completes the pattern?

A 

B 

C 

D 

E 

15 What number should go in the space to complete the following number pattern?

2, 4, ..., 48, 240

A 8
B 12
C 16
D 24
E 32

STOP. DO NOT CONTINUE UNTIL YOU ARE TOLD TO DO SO.

INTERNATIONAL SCIENCE STUDY

HIGH SCHOOL SCIENCE

BOOKLET 2

This part of the booklet has five sections, which contain questions about you, your parents, your science schoolwork, and your knowledge of words. Each section has a brief set of directions.

Each section corresponds to a section on your Answer Sheet. You should darken the circles of your Answer Sheet when answering these sections. Please be very careful when answering each question that you are using the correct section on the Answer Sheet and are at the appropriate circle for that response.

DIRECTIONS: On your answer sheet is a SCIENCE COURSE HISTORY form. This form has been duplicated below as an example. To fill out this form, blacken the circles that correspond to the type of science courses you have taken and the year in which you have taken them. Please include courses you are taking this year.

EXAMPLE: In the seventh grade, this student had a FULL year LIFE SCIENCE course. Therefore the Ⓕ circle under 7TH GRADE was blackened for LIFE SCIENCE.

In the eighth grade, this student studied a FULL year PHYSICAL SCIENCE course. Therefore the Ⓕ circle under 8TH GRADE was blackened for PHYSICAL SCIENCE.

In the ninth grade, this student had a FULL year of EARTH SCIENCE. Therefore the Ⓕ circle under 9TH GRADE was blackened for EARTH SCIENCE. In addition, this student studied HEALTH for part of the year. Since HEALTH was not on the list of courses, this student wrote the word "HEALTH" next to "OTHER" and blackened the Ⓟ under 9th graded.

Currently, this student is taking a beginning high school biology course. Since it is for the entire year, the student blackens the Ⓕ circle under 10TH GRADE for 1ST YEAR BIOLOGY.

SCIENCE COURSE HISTORY

Please fill in the appropriate circles to show which science subjects you have studied and the grade in which you studied. If you have studied this subject for a FULL year then blacken the Ⓕ. If you have studied the subject for PART of year then blackenen the Ⓟ.

	IN 7TH GRADE	IN 8TH GRADE	IN 9TH GRADE	IN 10TH GRADE	IN 11TH GRADE	IN 12TH GRADE
GENERAL SCIENCE ______	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
EARTH SCIENCE ______	Ⓕ Ⓟ	Ⓕ Ⓟ	● Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
LIFE SCIENCE ______	● Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
PHYSICAL SCIENCE ______	Ⓕ Ⓟ	● Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
ENVIRONMENTAL STUDIES –	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
1st YEAR BIOLOGY ______	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	● Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
1st YEAR CHEMISTRY ______	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
1st YEAR PHYSICS ______	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
2nd YEAR BIOLOGY ______	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
2nd YEAR CHEMISTRY ______	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
2nd YEAR PHYSICS ______	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
Other Health	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ ●	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
Other ______	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ
Other ______	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ	Ⓕ Ⓟ

SAMPLE ONLY

For other courses, please write the name of the course in the space provided.

When you have finished the SCIENCE COURSE HISTORY form, please continue by completing the rest of the booklet. Answer all questions on the answer sheet provided.

This Questionnaire contains questions about you, your parents, and your science schoolwork. The questions are to be answered by blackening the circle on the answer sheet for one of the letters--A, B, C, etc.

For this section, you can ask the test administrator for help if you have difficulty in understanding or answering a question.

1. What is your sex?

   A male

   B female

2. How many years of further education do you expect to complete after leaving high school?

   A I have not decided yet.

   B I do not expect to continue my education after leaving high school.

   C 1 - 2 years

   D 3 - 4 years

   E more than 4 years

3. For your further education, which one of the following best describes the kinds of courses you expect to be taking?

   A I have not decided yet.

   B I do not expect to continue my education after leaving high school.

   C Science and applied science (including medicine, computers, mathematics, engineering, and health field).

   D Social sciences (including psychology, sociology, history, and law).

   E Business and commercial studies.

   F Education, including teacher training.

   G Art, design, music, theater.

   H Agriculture, fishing, forestry.

   I English, foreign languages, journalism, communications.

   J Other

4. During week-days, about how many hours do you watch television?

A don't watch during the week

B some, but less than 1 hour

C about 1 hour

D about 2 hours

E about 3 hours

F about 4 hours

G about 5 hours

H 6 hours or more

5. About how many hours a week do you usually spend on homework or other school work out of class for all subjects (including science)?

A No homework is ever assigned.

B I have homework, but don't do it.

C up to 2 hours

D between 2 and 5 hours

E between 5 and 10 hours

F between 10 and 20 hours

G more than 20 hours

6. About how many hours a week do you usually spend on homework or other school work out of class for science subjects?

A No science homework is ever assigned.

B I have science homework, but don't do it.

C up to 2 hours

D between 2 and 5 hours

E between 5 and 10 hours

F more than 10 hours

7. Which one of the following best describes your grades so far in school?

   A Mostly A

   B About half A and half B

   C Mostly B

   D About half B and half C

   E Mostly C

   F About half C and half D

   G Mostly D

   H Mostly below D

8. Do you have an electronic calculator for your own use at school (either your own calculator or one supplied by the school)?

   A yes

   B no

9. Are there any computers (including microcomputers) at your school?

   A yes

   B no

10. How much time each week do you spend using a compûter (including microcomputers)?

   A I never use a computer at school.

   B up to two hours

   C between 2 and 5 hours

   D between 5 and 10 hours

   E more than 10 hours

11. After the eighth grade, how many years of mathematics have you studied?

A none

B one

C two

D three

E four

F more than four

12. What is the highest level of school your father (or step-father or male guardian) completed?

A Do not live with father (or step-father or male guardian).

B Grade school.

C Some high school.

D High school.

E Some education after high school (a vocational, trade, or business school).

F College or higher.

G I don't know.

13. Which one of these categories BEST describes your father's (or step-father's or male guardian's) work?

A Do not live with father (or step-father or male guardian).

B Semi-skilled: general work in a factory, farm, hospital, restaurant, service station, etc. (work that does not require a lot of training).

C Skilled: skilled work as a computer operator, electrician, mechanic, machinist (work that requires a lot of training and experience).

D Clerical and sales: work in an office, store, business, factory, post office, bank, etc.

E Professional and executive: work as a doctor, lawyer, engineer, accountant, teacher, manager, or person in charge, director, etc.

F Homemaker.

G Some other.

14. What is the highest level of school your mother (or [illegible] mother or female guardian) completed?

A Do not live with mother (or step-mother or female guardian).

B Grade school.

C Some high school.

D High school.

E Some education after high school (a vocational, trade, or business school).

F. College or higher.

G I don't know.

15. Which one these categories BEST describes your mother's (or step-mother's or female guardian's) work?

A Do not live with mother (or step-mother or female guardian).

B Semi-skilled: general work in a factory, farm, hospital, restaurant, service station, etc. (work that does not require a lot of training).

C Skilled: skilled work as a computer operator, electrician, mechanic, machinist (work that requires a lot of training and experience).

D Clerical and sales: work in an office, store, business, factory, post office, bank, etc.

E Professional and executive: work as a doctor, lawyer, engineer, accountant, teacher, manager, or person in charge, director, etc.

F Homemaker.

G Some other.

16 How many books are there in your home?

A none, or very few (1-10)

B a few books (11-25)

C about one bookcase full (26-100)

D about two bookcases full (101-250)

E about three or four bookcases full (251-500)

F a room full - a library (more than 500)

INTERNATIONAL SCIENCE STUDY OPINIONNAIRE PAGE 1

Directions

The purpose of the Opinionnaire is to let you tell us what you think about science and about the school you attend. This is not a test, and there are no right or wrong answers.

Please give your opinion for each statement by blackening the circle on your Answer Sheet for one of the following letters:

A if you agree with the statement

D if you disagree with the statement

U if you are uncertain or you don't know

You may ask the test administrator for help if you have difficulty in understanding the questions.

		AGREE	DISAGREE	UNCERTAIN
1.	Science is useful for solving the problems of everyday life.	A	D	U
2.	I find school challenging.	A	D	U
3.	Science has ruined the environment.	A	D	U
4.	Working in a science laboratory would be an interesting way to earn a living.	A	D	U
5.	Science is very important for a country's development.	A	D	U
6.	School is not very enjoyable.	A	D	U
7.	Money spent on science is well worth spending.	A	D	U
8.	In the future, most jobs will require a knowledge of science.	A	D	U
9.	Much of the anxiety in modern society is due to science.	A	D	U
10.	People who understand science are better off in our society.	A	D	U
11.	It is important to know science in order to get a good job.	A	D	U
12.	I am bored most of the time in school.	A	D	U

	AGREE	DISAGREE	UNCERTAIN
13. Scientific inventions improve our standard of living.	A	D	U
14. There are many school subjects I don't like.	A	D	U
15. Scientific inventions have increased tensions between people.	A	D	U
16. In my future career, I would like to use the science I learned at school	A	D	U
17. Science will help to make the world a better place in the future.	A	D	U
18. Scientific discoveries do more harm than good.	A	D	U
19. Science and technology are the cause of many of the world's problems.	A	D	U
20. I generally dislike my schoolwork.	A	D	U
21. I would like to become a science teacher when I leave school.	A	D	U
22. Science is an enjoyable school subject.	A	D	U
23. The science taught at school is interesting.	A	D	U
24. Science is a difficult subject.	A	D	U
25. Science is difficult when it involves calculations.	A	D	U
26. Science is difficult when it involves handling apparatus.	A	D	U
27. There are too many facts to learn in science.	A	D	U
28. Science is relevant to everyday life.	A	D	U

Directions:

This section contains statements describing activities which take place when students are learning science.

Please state what takes place when you are learning science by blackening the circle on your Answer Sheet for one of the letters:

O if it often takes place

S if it sometimes takes place

N if it never takes place

You may ask the test administrator for help if you have difficulty in understanding the questions.

		OFTEN	SOMETIMES	NEVER
1.	We use a textbook during science lessons.	O	S	N
2.	When I have science homework, I hand it in on time.	O	S	N
3.	At the start of each science lesson the teacher reminds us about the work we covered during the previous lessons.	O	S	N
4.	At the start of each science lesson the teacher explains the work we have to cover during the lesson.	O	S	N
5.	At the end of each science lesson the teacher gives a summary of what was taught in the lesson.	O	S	N
6.	When I sit down to do my science homework, I start right away.	O	S	N
7.	The teacher uses our ideas and suggestions when planning science lessons.	O	S	N
8.	The teacher does demonstrations to help explain scientific ideas.	O	S	N

		OFTEN	SOMETIMES	NEVER
9.	The teacher makes science lessons interesting for us.	O	S	N
10.	When I do my science homework, I am distracted by things going on aound me.	O	S	N
11.	For science homework we write up reports of our laboratory project work.	O	S	N
12.	The teacher explains how the science we learn is relevant to our own lives.	O	S	N
13.	The teacher discusses possible careers in science with us.	O	S	N
14.	We have tests on what we have learned in science.	O	S	N
15.	The science teacher helps students who have difficulties with learning science.	O	S	N
16.	When I have science homework, I attempt to do all of it.	O	S	N
17.	We do field work outside the classroom as part of our science lessons.	O	S	N
18.	We do laboratory work as part of our science lessons.	O	S	N
19.	The science class breaks into small groups of students to do laboratory work.	O	S	N
20.	When we do experiments, the teacher gives us instructions about what to do.	O	S	N
21.	When we do an experiment we use a book or other written instructions to show us how to do it.	O	S	N
22.	In our laboratory work we make up our own problems and then the teacher helps us to plan experiments to solve them.	O	S	N
23.	When we do experiments the teacher gives us problems to solve and then leaves us to work out our own methods and solutions.	O	S	N
24.	In our laboratory work we make up our own problems and work out our own methods to investigate the problems.	O	S	N

INTERNATIONAL SCIENCE STUDY — WORD KNOWLEDGE PAGE 1

Directions

In this test words are given to you in pairs. In each pair, the two words have something in common. You must decide whether the words mean nearly the same thing, or nearly the opposite thing, with respect to what they have in common.

If you think the words have the same meaning, blacken the circle Ⓢ .

If you think the words have the opposite meaning, blacken the circle Ⓞ .

Here is an example:

High Low Ⓢ Ⓞ

Two two words 'high' and 'low' both refer to height. However, they are nearly opposite in meaning. Therefore you should blacken the circle '0'.

For each of the following pairs, blacken the 'S' or the 'O' like you did in the example above. You should attempt every item for which you think you know the answer, but do not guess if you have no idea of the answer. Place your responses on the answer sheet.

			Same	Opposite
1	savory	insipid	S	O
2	precarious	stable	S	O
3	supple	malleable	S	O
4	mute	voluble	S	O
5	prosperity	opulence	S	O
6	adjacent	contiguous	S	O
7	garrulous	taciturn	S	O
8	expatiate	harangue	S	O
9	acquire	dispel	S	O
10	abstruse	explicit	S	O

INTERNATIONAL SCIENCE STUDY

WORD KNOWLEDGE PAGE 2

11	flagrant	obvious	S	O
12	paltry	exorbitant	S	O
13	absolute	relative	S	O
14	converge	approach	S	O
15	consecrate	dedicate	S	O
16	deny	repeal	S	O
17	variable	inconstant	S	O
18	bounty	generosity	S	O
19	delicate	tactful	S	O
20	repudiate	disavow	S	O
21	obvious	indisputable	S	O
22	adorned	embellished	S	O
23	installed	deposed	S	O
24	level	plane	S	O
25	impervious	accessible	S	O
26	hilarious	melancholic	S	O
27	miser	prodigal	S	O
28	dishonorable	infamous	S	O
29	immutable	fluctuating	S	O
30	abolish	abrogate	S	O

APPENDIX C

SISS-U.S. ADVANCED SCIENCE TEACHER QUESTIONNAIRE

International Science Study

Teacher Questionnaire

Supported by
National Science Foundation

Conducted by
Columbia University
Research Triangle Institute

The Second International Science Study is being conducted with the support of the National Science Foundation. While you are not required to respond, your cooperation is needed to make the results of this study comprehensive, accurate, and timely. All information that would permit identification of an individual, a school, or a school district will be held in strict confidence.

INSTRUCTIONS

This questionnaire contains questions about you, your education, your teaching experience, and your teaching techniques.

Using a #2 or softer pencil, please indicate your sex and the course you teach by darkening the appropriate circle on the Answer Sheet. Note that the identification number of your school for this study has been precoded.

Now, please answer the questions on the following pages by darkening the appropriate circles on the Answer Sheet.

1 What is your age?

- A 27 years or younger
- B 28 - 37 years
- C 38 - 47 years
- D 48 - 57 years
- E 58 years or older

2 How many years of full-time, college education have you completed? (Include part-time education by summing it to its full-time equivalent.)

- A no further education after leaving secondary school
- B up to 2 years
- C between 2 and 4 years
- D between 4 and 6 years
- E more than 6 years

3 How much of your college education was spent on studying science subjects?

- A no further education after leaving secondary school
- B no study of science at the college level
- C 25% or less of college education involved science subjects
- D between 25% and 50% of college education involved science subjects
- E more than 50% of college education involved science subjects

4 Including this year, how many years of teachinge experience have you had? (Include part-time teaching by summing it to its full-time equivalent.)

- A up to 5 years
- B between 5 and 10 years
- C between 10 and 20 years
- D between 20 and 30 years
- E more than 30 years

5 Are you certified to teach the class being tested?

A yes

B no

6 Which of the following science fields are you certified to teach? (Darken the circle for all that apply.)

Physics

Biology

General Science

Life Science

Science (N-9)

Chemistry

Earth Science

Physical Science

Middle/Jr. High School

Elementary Grades

Other (please specify)

7 Do you now have teaching resposibilities in science which are outside your area of ceritification?

A yes

B no

8 Please indicate the annual gross salary you receive as a teacher. (Please note that this item is optional, but it would be of great value to the study if you would answer it.)

A less than $15,000
B $16,000 - $20,000
C $21,000 - $25,000
D $26,000 - $30,000
E more than $30,000

9 Do your students use electronic calculators during science lessons?

A frequently
B occasionally
C rarely
D never

10 Do you have access to a computer at school for use in your science teaching?

A yes
B no

11 How often do you or your students use a computer during science lessons?

A frequently
B occasionally
C rarely
D never

12 Are you a member of a science teachers or science association?

A yes
B no

13 How often do you read academic journals or other periodicals related to teaching in general?

A each week
B each month
C occasionally (several times a year)
D rarely or never

14 How often do you read journals or periodicals on science subjects?

A each week
B each month
C occasionally (several times a year)
D rarely or never

15 During the last 12 months, what is the total amount of time you have spent on inservice training related to science or the teaching of science. Please include meetings or conferences on science education as well as formal courses in science subjects. Convert sessions of less than one day into the equivalent number of full days. (Six hours of training equals one day.)

A none
B less than one day
C 1 - 2 days
D 3 - 5 days
E more than 5 days

16 How much of your teaching of science takes place in a room or laboratory equipped for science teaching and/or student laboratory work?

A none
B some, but less than 40 prcent
C 41 - 60 percent
D 61 - 80 percent
E more than 80 percent

17 How many hours per week (on the average) do you spend outside school hours marking tests and examinations and preparing lessons for all subjects you teach, including science?

A up to 3 hours
B between 3 and 6 hours
C between 6 and 10 hours
D between 10 and 15 hours
E more than 15 hours

FOR QUESTIONS 18-21, PLEASE SELECT THE APPROPRIATE ANSWER FROM THE FOLLOWING KEY AND BLACKEN THE CORRESPONDING LETTER ON YOUR ANSWER SHEET.

KEY:		
	A	less than 5 hours
	B	between 5 and 10 hours
	C	between 10 and 15 hours
	D	between 15 and 20 hours
	E	more than 20 hours

18 How many hours do you spend at school in a typical school week teaching science subjects?

19 How many hours do you spend at school in a typical school week teaching mathematics subjects?

20 How many hours do you spend at school in a typical school week teaching other subjects?

21 How many hours do you spend at school in a typical school week marking tests and examinations and preparing lessons.

For questions 22 - 29, please select the appropriate answer from the following key and blacken the corresponding letter on your answer sheet.

KEY:	A	very important
	B	of some importance
	C	of little importance
	D	of no importance
	E	does not apply

HOW IMPORTANT ARE EACH OF THE FOLLOWING IN DETERMINING WHAT YOU TEACH?

22 what the students will need when they leave school

23 the official curriculum or syllabus

24 prescribed textbook(s)

25 the external examinations that the students will have to take

26 what the students will need in the next grade or in the next science course

27 developing the ability of the students to think scientifically

28 helping the students to acquire a systematic knowledge of scientific concepts

29 availability of laboratory equipment

For questions 30 - 39, please select the appropriate answer from the following key and blacken the corresponding letter on your answer sheet.

KEY:		
	A	frequently
	B	occasionally
	C	rarely
	D	never

30 In the teaching of science, how often do you use question-and-answer methods?

31 In the teaching of science, how often do you lecture to the class?

32 In the teaching of science, how often do all students do the same assignment?

33 In the teaching of science, how often is your class divided into small groups of students?

34 In the teaching of science, how often do students follow individualized programs in your class?

35 In the teaching of science, how often do you use audio-visual materials in your class?

36 In the teaching of science, how often does your class go on science field trips?

37 In the teaching of science, how often do you have guest speakers come in to talk to your class?

38 In the teaching of science, how often do you present science demonstrations to your class?

39 In the teaching of science, how often do your students perform laboratory experiments?

For questions 40-49, please select the appropriate answer from the following key and blacken the corresponding letter on your answer sheet.

KEY:	A	frequently
	B	occasionally
	C	rarely
	D	never

40 In assessing the work of your science students, how often do you use standardized tests produced outside the school?

41 In assessing the work of your science students, how often do you use teacher-made essay tests (requiring at least one paragraph of writing)?

42 In assessing the work of your science students, how often do you use teacher-made objective (short-answer) tests?

43 In assessing the work of your science students, how often do you make use of performance on homework assignments?

44 In assessing the work of your science students, how often do you make use of performance on laboratory exercises and/or projects?

INTERNATIONAL SCIENCE STUDY

TEACHER OPPORTUNITY RATING

The tests being administered to your students assess a wide variety of science concepts. These concepts may not be stressed uniformly in all countries. Your responses will help us to determine the degree of emphasis on these concepts in schools in the United States. The teachers of all the science classes tested are being asked to indicate the opportunity their students have had to learn the concepts tested by each question.

To simplify your rating, we have assembled all the test questions administered to your students into this one booklet.

In order to facilitate our collection and interpretation of this data, please enter your ratings on Side 2 of the enclosed Answer Sheet, beginning with Number 101.

(NOTE: A copy of the respective test items followed.)

For each question in the test, please blacken the circle for one of the letters--A, B, C, D, or E to indicate where all or most of the students in your class may have had the opportunity to learn the concept tested by each question:

A during a previous year's science course

B during this year's science course

C in a future science course in this school

D not in any part of the science program at this school

APPENDIX D

SISS-U.S. ADVANCED SCIENCE SCHOOL QUESTIONNAIRE

School ID ☐☐☐☐

International Science Study

School Questionnaire

Grades 9-12

Supported by
National Science Foundation

Conducted by
Columbia University
Research Triangle Institute

The Second International Science Study is being conducted with the support of the National Science Foundation. While you are not required to respond, your cooperation is needed to make the results of this study comprehensive, accurate, and timely. All information that would permit identification of an individual, a school, or a school district will be held in strict confidence.

INSTRUCTIONS

Please complete the questions in this booklet by either circling the letter for the appropriate response or by entering the answer in the appropriate space.

1 Which of the following best describes the area served by your school?

A an inner urban part of a metropolitan area
B an outer urban/suburban part of a metropolitan area
C an urban/suburban area but not part of a metropolitan area
D a rural area

2 What is the approximate population of the area served by your school?

A more than 1,000,000
B 100,000 - 1,000,000
C 10,000 - 100,000
D 1,000 - 10,000
E less than 1,000

3 Is the school week in your school divided into periods?

A yes - please go on to question 4

B no - please go on to question 6

4 How many periods are in a school week?

A 20 periods or less
B 21 to 30 periods
C 31 to 40 periods
D 41 to 50 periods
E more than 50 periods

5 What is the number of minutes in each period?

A 20 minutes or less

B 21 to 30 minutes

C 31 to 40 minutes

D 41 to 50 minutes

E more than 50 minutes

6 What is the number of hours in a school week? Please include time allocated to scheduled activities such as lessons, sport and assemblies, but exclude time allocated to recess and lunch breaks.

A 20 hours or less

B 21 to 25 hours

C 26 to 30 hours

D 31 to 35 hours

E more than 35 hours

7 What is the number of days in a school year? Please exclude time allocated to vacations.

A 170 days or less

B 171 to 180 days

C 181 to 190 days

D 191 to 200 days

E more than 200 days

8. What is the minimum number of years of high school science (grades 9-12) required of students for graduation from your school (except special education students)?

A none or less than one year are required

B 1 year

C 2 years

D 3 years

E 4 years

9. What is the minimum number of years of high school math (grades 9-12) required of students for graduation from your school (except special education students)?

A none or less than one year are required

B 1 year

C 2 years

D 3 years

E 4 years

10. How many rooms or laboratories in your school are equipped for science teaching and/or student laboratory work?

A none

B 1

C 2 - 4

D 5 - 9

E 10 rooms or more

11. Please estimate the overall percentage of the school week for which these science rooms are used for science lessons or laboratory work.

A less than 40 percent of the week

B 41 - 60 percent of the week

C 61 - 80 percent of the week

D more than 80 percent of the week

E no science rooms at this school

12. How many science laboratory assistants or technicians (full-time equivalent) are there in your school?

A none

B 1

C 2

D 3

E 4 or more

13. What is the source of operating costs for your school? (For example, salaries for teaching and non-teaching staff, maintenance and repairs.)

A totally or almost wholly provided by local and state taxes

B partially provided by local and state taxes

C totally or almost wholly provided by private sources (including fees paid by students)

14. Does your school have a committee, organization, or association on which both parents and teachers are formally represented?

A yes

B no

15. Is organization of science-related activities (e.g. science fairs, industry visits, career information) arranged or carried out by groups involving both parents and/or teachers?

A yes

B no

I. How many students are presently in the following grade levels in your school? If a grade level is not in your school, please indicate with a dash.

Grade Level	Male Students	Female Students
K		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

II. Approximately how many students in grades 9-12 are enrolled in the following science courses in your school this year?

	Male	Female
Biology (First Year)		
Advanced Biology (Second Year)		
Environmental Science/Ecology		
Chemistry (First Year)		
Advanced Chemistry (Second Year)		
Physics (First Year)		
Advanced Physics (Second Year)		
Physical Science		
Earth Science		
Life Science		
General Science (Science 9)		
Unified Science		
Other (please specify)		

III. What is the total number of male and female teachers at your school (grades 7-12)? Please include part-time teachers by summing them to their full-time equivalent.

_________ male teachers _________ female teachers

IV. What is the number (full-time equivalent) of male and female teachers at your school who teach science subjects at the secondary grade level (7-12)?

________ male teachers of science ________female teachers of science

V. For your school, approximately how much money was spent during this current school year for the purchase of*:

________ A. Non-expendable science equipment (e.g., balances, meters, microscopes, stream tables)?

________ B. Consumable science supplies (e.g., batteries, chemicals, glassware, seeds, specimens)?

________ C. Science texts, lab guides, workbooks, etc.

________ D. Other (e.g., science field trip). Please specify.

____

*Please exclude normal classroom materials, such as chalk, paper, etc.

COMMENTS:

Please use this section for additional information or explanations related to any of the questions which you would care to provide. Please feel free to continue your comments on the reverse side of the page.

APPENDIX E

SISS-U.S. ADVANCED SCIENCE TESTS

SISS-U.S. Advanced Biology

International Science Study

Second Year Biology

Booklet 1

Supported by
National Science Foundation

Conducted by
Columbia University
Research Triangle Institute

The Second International Science Study is being conducted with the support of the National Science Foundation. While you are not required to respond, your cooperation is needed to make the results of this study comprehensive, accurate, and timely. All information that would permit identification of an individual, a school, or a school district will be held in strict confidence.

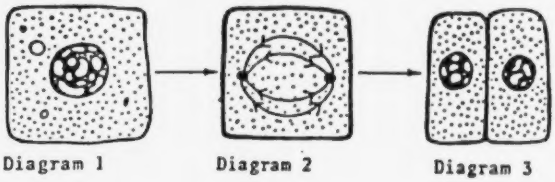
INSTRUCTIONS

This test contains questions about biology. Each of the questions is followed by five suggested answers, shown by the letters A, B, C, D, and E. For each question you must choose the one answer you think is correct. In the section of the Answer Sheet headed SCIENCE TEST-BOOKLET 1, darken the circle for the appropriate letter.

If you do not know the answer to a question, leave it and go on to the next question. You can come back to this question later. You may answer questions even if you are not sure, but do not guess blindly.

You will have 45 minutes to complete the booklet. Please do not begin until you are told to do so.

1 The following diagrams represent a cell process.



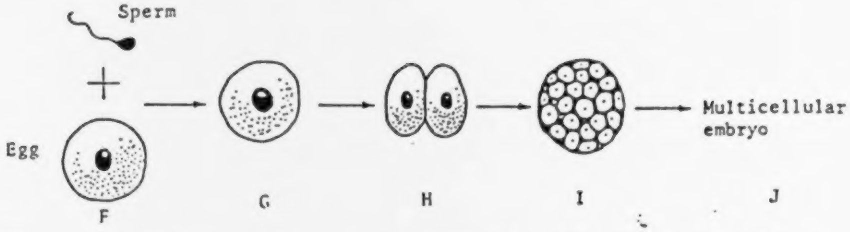
If the cell in Diagram 1 contains four chromosomes, how many chromosomes would be present in each cell in Diagram 3?

A 1
B 2
C 4
D 8
E 16

2 What initially determines whether a human baby is going to be a male or a female?

A The DNA in the sperm.
B The DNA in the egg.
C The RNA in the sperm.
D The RNA in the egg.
E The DNA and RNA in both sperm and egg.

3



Where would the process which occurs between F and G normally take place in humans?

A uterus
B ovary
C testis
D oviduct
E vagina

4 The diagrams represent three cells with membranes of different permeability. The dots show sugar molecules which cannot pass through the cell membrane.

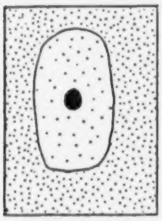


Diagram 1

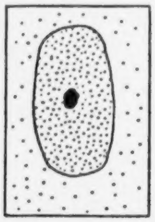


Diagram 2

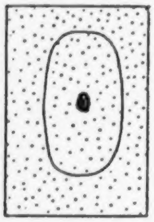
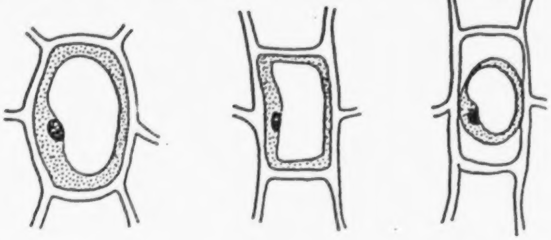


Diagram 3

Into which cell(s) will the most water molecules diffuse in from the outside?

A 1 only
B 2 only
C 1 and 2 only
D 2 and 3 only
E 1, 2, and 3

5 Similar fragments of a certain plant tissue were placed in 1%, 9%, and 15% sugar solutions respectively. When viewed under the microscope after they had reached equilibrium with the bathing solution, single cells appeared as shown in the diagrams for the three solutions.



1 per cent solution — Diagram 1

9 per cent solution — Diagram 2

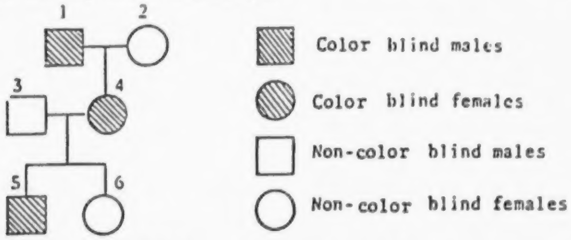
15 per cent solution — Diagram 3

The differences shown in the three drawings are due to properties of the cell and its surrounding solution.

Suppose the same experiment is carried out using a salt solution instead of a sugar solution. What will fill the space between the cell wall and the protoplast in diagram 3?

- A water
- B air
- C salt solution
- D ectoplasm
- E cell sap

6 The next question is based on the following human pedigree of a sex-linked trait, color blindness.



What person(s) could have no genes for color blindness?

- A 2 only
- B 3 only
- C 2 and 3
- D 3 and 6
- E 6 only

7 Two alternative color characteristics in mice are "hooded" and "white" When homozygous parents of both colors are crossed all the offspring are hooded. If these F_1 hooded rats are mated together and produce litters totalling 50 rats, which of the following proportions is most likely?

A 50 hooded : none white
B 50 white : none hooded
C 38 white : 12 hooded
D 24 white : 26 hooded
E 10 white : 40 hooded

8 In a population of 1000 fruit flies, the percentages of gene pairs were:

TT = 15 per cent Tt = 51 per cent tt = 34 per cent.

If the fruit flies were free to breed normally, and if nothing happened to disturb the "gene pool", what would be the approximate percentage of tt two generations later?

A 15 per cent
B 34 per cent
C 51 per cent
D 68 per cent
E 75 per cent

9 In many breeds of cattle the polled condition (absence of horns) is dominant over the presence of horns, and homozygous red crossed with homozygous white produces roan (intermingled red and white hairs) color . Which of the following crosses will produce only horned roan offspring?

A polled red x horned white
B horned roan x horned roan
C horned red x horned white
D polled roan x horned roan
E polled white x horned roan

10 Which of these substances is found in every living cell?

A protein

B chlorophyll

C cellulose

D starch

E hemoglobin

11 How does lymph enter the tissues of humans?

A by blood pressure

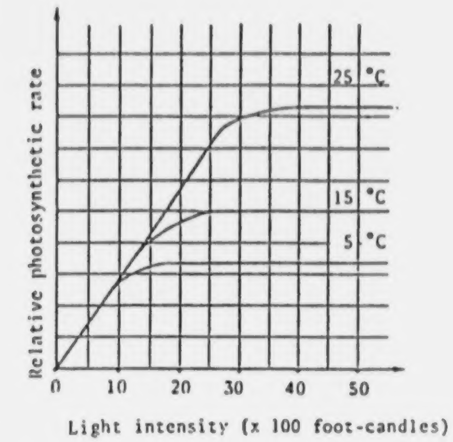
B by the action of the liver

C by the action of the intestinal villi

D by the action of the kidney

E by a diffusion gradient

12 In an experiment with a certain plant, the photosynthetic rate per unit of a leaf area was measured at different light intensities. The experiment was repeated at three different temperatures, 5°C, 15°C, and 25°C. An adequate supply of carbon dioxide was maintained throughout the experiments. The graph shows the results.



On the basis of the data given in the graph, which factor or factors determine the phytosynthetic rate in light intensities more than 3,000 foot-candles?

- A light intensity
- B temperature
- C temperature and light intensity
- D water status of plant
- E no factor can be ascertained from the graph.

13 What happens first when chlorophyll absorbs light in a living plant cell?

A Carbon dioxide is fixed into phosphoglyceric acid.

B Carbohydrates are formed.

C Adenosine triphosphate (ATP) is converted into adenosine diphosphate (ADP).

D Adenosine diphosphate (ADP) is converted into adenosine triphosphate (ATP) and hydrogen is released from water.

E Oxygen is released from carbon dioxide.

14 The primary function of a kidney tubule is to reabsorb water. The diagrams show three types of kidney tubules (nephrons).

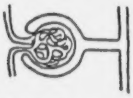


Diagram 1

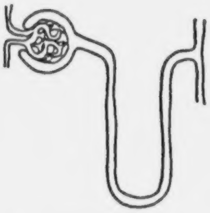


Diagram 2

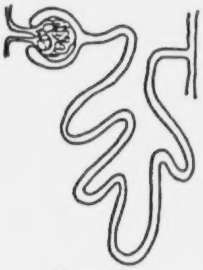


Diagram 3

Which kidney tubule (nephron) is most likely to occur in a desert animal?

A 1

B 2

C 3

D It will depend on whether the animal is cold blooded or warm blooded.

E It will depend on whether the animal is a herbivore or a carnivore.

15 Tissue from a cow is shown on analysis to contain protein, a small amount of fat, some iron, and large quantities of vitamins A and D. Which part of the body did it come from?

A muscles

B kidney

C liver

D heart

E brain

16 In slightly diluted sea water, the small marine worm Gunda swells when deprived of oxygen and shrinks again when oxygen is supplied. What is the most likely explanation?

A Lack of oxygen results in an incomplete oxidation of waste products.

B The lack of oxygen increases water absorption.

C Excess water is poisonous to the organism.

D When less oxygen is available, there is not enough energy to oppose entry of water by means of osmosis.

E An increase of surface area gives a better means of oxygen absorption.

17 Which one of the following processes in plants is not controlled by hormones?

A water uplift in the stem

B downward growth of the radicle

C flowering under the influence of increasing day length

D falling of the leaves of deciduous trees in autumn

E orientation of shoots towards lateral light

18 Secretions of endocrine organs in animals are not directly responsible for which one of the following?

A calcium metabolism

B secretion by the adrenal cortex

C changes in the uterine lining

D changes of body temperature

E general body growth

19 Cobalt chloride paper is blue when dry. It gradually changes color to pink in the presence of water vapor. Three 1 cm^2 dry cobalt chloride papers were treated as follows:

The first was fastened to the upper surface of a leaf by means of a clip, the second to the lower surface in a similar way, and the third hung free in the air. The time taken for the papers to achieve a standard pink color was noted. The first took 9 minutes, the second 12 minutes, the third 18 minutes.

Which of the following conclusions is justified on this evidence alone?

A There are more stomata on the lower surface of the leaf than on the upper.

B No water vapor is given off from the lower surface of the leaf.

C The upper leaf surface gives off more water vapor than the lower.

D Both leaf surfaces give off water vapor at the same rate.

E There are no stomata on the upper surface of the leaf.

20 In order to obtain two crops in one growing season a farmer planted some seeds which he had harvested the previous week but the seeds failed to germinate. What can be concluded from this observation?

A The farmer did not provide the right conditions for germination.

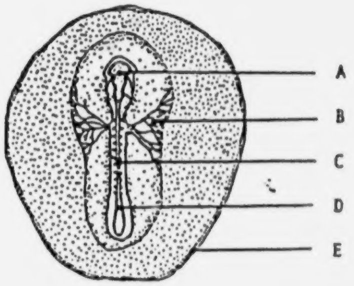
B The seeds needed a longer period of maturation.

C The farmer had not removed inhibiting substances.

D The seeds required a period of low temperature.

E The data are inadequate for a conclusion to be reached.

21 The diagram shows a 33-hour chick embryo. Which structure brings food to the growing embryo?



22 The following results are from experiments which were made to find how long it took for newborn babies of different mammals to double in weight.

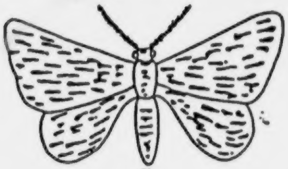
Mammal	Time in days to double the weight of the newborn baby	Percentage protein in the milk of the mother
human	180	1.6
horse	60	2.0
cow	47	3.5
pig	18	5.9
sheep	10	6.5
dog	8	7.1
rabbit	6	10.4

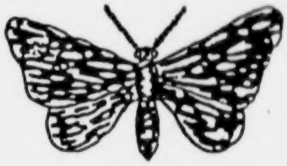
What do the results of these experiments suggest?

- A The larger the mammal, the greater the protein concentration in the milk.
- B The smaller the mammal, the greater the protein concentration in the milk.
- C The greater the protein concentration in the mammal's milk the slower the newborn baby will double its weight.
- D The greater the protein concentration in the mammal's milk the faster the newborn baby will double its weight.
- E There appears to be no relationship between protein concentration in mammal's milk and time taken for a newborn baby to double its birth weight.

23 The following item refers to the drawings and the descriptive paragraph below.

X and Y represent two forms of the same moth, a light speckled form and a predominantly dark, or melanic, form.


X


Y

During the 19th century the air in some parts of England became increasingly polluted with soot through the growth of industry based on the burning of coal. One effect of this pollution was that lichens would no longer grow on the trunks and branches of trees as these became blackened with soot.

Until 1850 the only form of this moth that had been recorded was the light form X. Then in 1850 the dark form Y was reported from one of these industrial areas. By the end of the 19th century the dark form had become quite common and now it is, in many localities, the commoner of the two forms, especially in the vicinity of large towns, where it often comprises as much as 95% of the total population, although the light form predominates in areas away from large centers of population.

Which of the following best explains the appearance of the dark specimen in 1850?

A The color change was induced by air pollution.

B The organisms adapted themselves to the change in external environment.

C Air pollution affected the moths directly after their emergence from the pupal stage.

D A mutation, that had occurred before but had failed to become established, became established because it was favored by changes in the external environment.

E The caterpillars ate soot contaminated leaves and dark moths developed from them.

24 All of the following are aspects of the reproductive process. Which one of them must occur before we can be certain that fertilization has taken place?

A A male organism must find a mate.

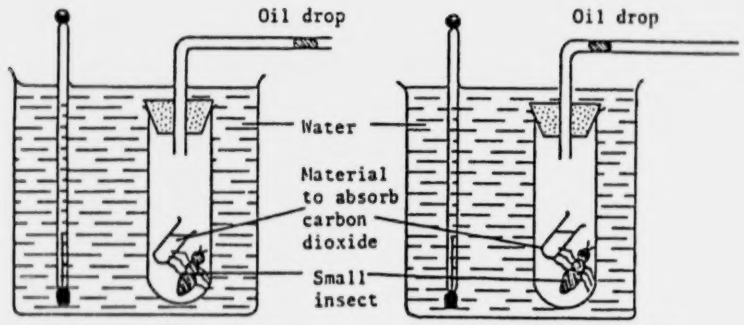
B Reproductive organs must be produced.

C The nucleus of a male gamete must fuse with that of a female gamete.

D A spermatozoon must reach an egg cell.

E A female gamete must provide a store of food for the embryo.

25 Animals take in oxygen and give out carbon dioxide. Ordinary air contains very little carbon dioxide.



Apparatus as first set up

Apparatus after 5 minutes

Which of the following can be measured with the above apparatus?

A The rate of movement of the animal.

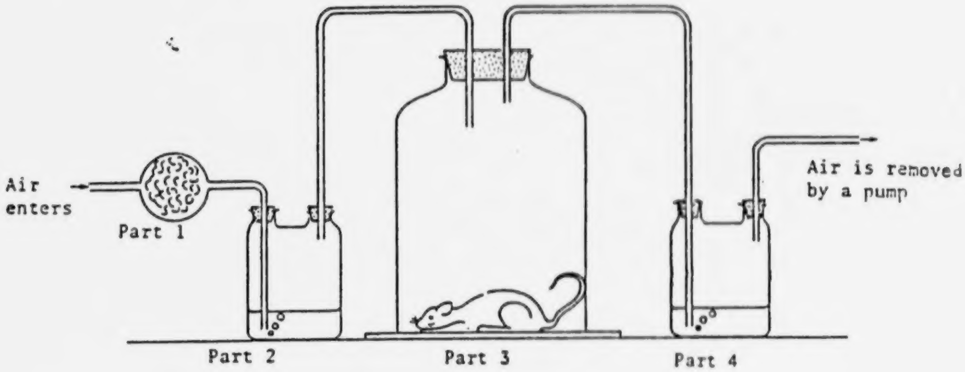
B The amount of heat produced by the animal.

C The rate of respiration of the animal.

D The effect of carbon dioxide on the animal.

E The amount of carbon dioxide absorbed by the animal.

26 This question refers to the following diagram of apparatus used to show that an animal gives out carbon dioxide in respiration.



Part 1 contains a substance which removes carbon dioxide from the air passing through it. Parts 2 and 4 both contain a liquid which changes in appearance when carbon dioxide passes through it.

Of the following kinds of containers for the animal which one would give the quickest result?

A a small container

B a large container

C a container in bright light

D a container covered with a dark cloth

E a container in which the air is kept moist by means of a wet cotton ball

27 How does natural selection operate in a population?

A The members are all alike.

B The members are equally able to survive any environmental change.

C The members differ so only some survive when the environment changes.

D The members do not adapt to environmental changes.

E The members of the entire population adapt to environmental changes.

28 It has been noticed in recent years that the proportion of insects surviving after exposure to certain insecticides has shown a gradual increase with succeeding generations. Of the following, which is the best explanation?

A World changes in climate have provided a new environment.

B Offspring of insects which have been exposed to the insecticide have inherited an immunity.

C Elimination of the less resistant strains gives the resistant ones a greater chance of success

D Changes in the habits of the insects have enabled them to survive.

E The insecticide causes favorable mutations.

29 The Galapagos Islands in the Pacific are believed never to have been connected to the mainland. In the Islands there are about 14 species of finch-like birds with few obvious relatives except on the South American mainland. The finches vary from island to island. There is a close resemblance between species in plumage, calls, nests, and eggs, but each species differs greatly in beak structure according to the diet. The species do not interbreed and do not compete for food.

It is stated on this evidence that isolation from the South American mainland and different habitats on the Islands are important factors in the production of new species.

A The statement is supported by the information given.

B The statement is not supported by the information given.

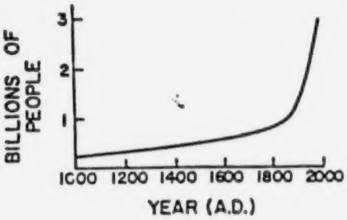
C The statement is contradicted by the information given.

D The statement is known to be false but this is not supported by the information given.

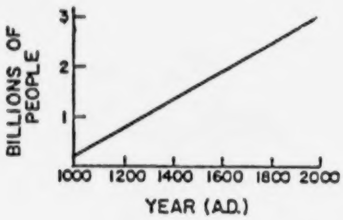
E No relevant information is given.

30 Which graph best shows the human population growth in the world during the past 1,000 years?

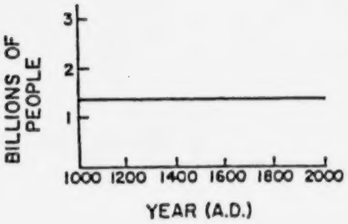
A



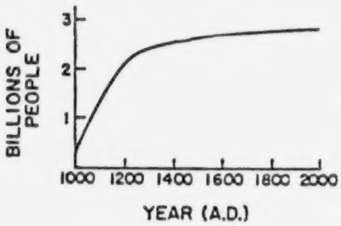
B



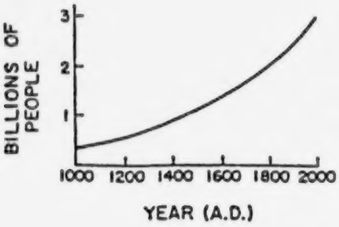
C



D



E



A Graph A

B Graph B

C Graph C

D Graph D

E Graph E

International Science Study

Second Year Chemistry

Booklet 1

Supported by
National Science Foundation

Conducted by
Columbia University
Research Triangle Institute

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INSTRUCTIONS

This test contains questions about chemistry. Each of the questions is followed by five suggested answers, shown by the letters A, B, C, D, and E. For each question you must choose the one answer you think is correct. In the section of the Answer Sheet headed SCIENCE TEST-BOOKLET 1, darken the circle for the appropriate letter.

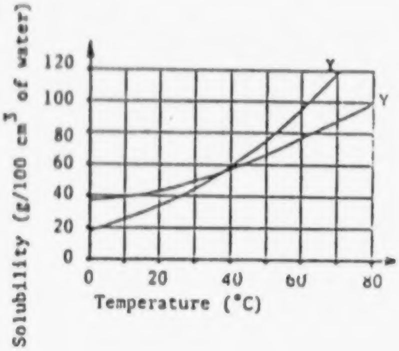
If you do not know the answer to a question, leave it and go on to the next question. You can come back to this question later. You may answer questions even if you are not sure, but do not guess blindly.

You will have 45 minutes to complete the booklet. Please do not begin until you are told to do so.

1 The solubility of a solid in water may be expressed as the number of grams of solid that can dissolve in 100 cm^3 of water. Which one of the following does the solubility depend on?

- A the volume of water used
- B the temperature of the water
- C the density of the solid
- D the mass of the solid used
- E the size of the particles of the solid

2 The graph shows the solubility of two substances X and Y. A sample of 150 g of X and 75 g of Y is placed in a beaker containing 100 cm^3 of water. Assume that the placing of the two substances together has no effect on how either dissolves. The mixture is filtered at 60 °C. What would the residue on the filter paper consist of?



- A 95 g of X and 15 g of Y
- B 55 g of X and 75 g of Y
- C 95 g of X
- D 75 g of Y
- E 55 g of X

3 When 2 g (grams) of zinc and 1 g of sulfur are heated together, practically no zinc or sulfur remains after the compound zinc sulfide is formed. What happens if 2 g of zinc are heated with 2 g of sulfur?

- A Zinc sulfide containing approximately twice as much sulfur is formed.
- B Approximately 1 g of sulfur will be left over.
- C Approximately 1 g of zinc will be left over.
- D Approximately 1 g of each will be left over.
- E No reaction will occur.

4 The following apparatus is set out on a laboratory bench: two vacuum (thermos) flasks, two thermometers, two measuring cylinders, a beaker containing 1 M (mol/liter) sodium hydroxide solution and a beaker containing 1 M hydrochloric acid.

Which one of the following procedures would give data from which you could most accurately obtain a value for the heat evolved in the neutralization of one mole of sodium hydroxide with hydrochloric acid?

- A Take the temperatures of the acid and alkali in their respective beakers, mix them in a vacuum flask and record the rise in temperature produced.
- B Mix the acid and alkali in one vacuum flask, record the temperature, transfer the contents to the second flask and record any change in temperature.
- C Allow all the acid and half the volume of alkali to come to steady recorded temperatures in the respective vacuum flasks, mix them and record the temperature rise produced.
- D Allow equal volumes of acid and alkali to come to steady recorded temperatures in the respective vacuum flasks, mix them and record the temperature rise produced.
- E With a known volume of acid in the one vacuum flask record the temperature at regular intervals of time as alkali is added from the other flask.

5 During electrolysis, which of the following is produced by 1.0 faraday of electricity (1.0 mol of electrons)?

- A 1.0 mol of H_2 from H_2SO_4 aqueous solution
- B 1.0 mol of O_2 from H_2SO_4 aqueous solution
- C 1.0 mol of Cl_2 from NaCl aqueous solution
- D 1.0 mol of Cu atoms from $CuSO_4$ aqueous solution
- E 1.0 mol of Ag atoms from $AgNO_3$ aqueous solution

6 When 16 g of dilute sulfuric acid is poured onto 3 g of zinc in an open test tube, hydrogen gas is generated. What is the weight of the contents of the test tube after the reaction is completed?

A slightly more than 19 g

B slightly less than 19 g

C equal to 19 g

D slightly less than 16 g

E equal to 16 g

7 Copper reacts with concentrated sulfuric acid as represented by the following equation:

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$$

Which one of the following statements about the reaction is true?

A Copper is oxidized.

B Sulfuric acid is oxidized.

C Sulfuric acid is the reducing agent.

D Copper is reduced.

E Hydrogen is the reducing agent.

8 A solution of substance X is added to a solution of substance Y. No color change is observed. Which of the following would provide evidence that a chemical reaction had taken place although there was no change in color?

A Any product is soluble in water.

B The solutions of X and Y can be mixed in all proportions and still give the same result.

C There is a rise of temperature when the two solutions are mixed.

D The final liquid is shown to be neutral by using an indicator.

E The experiment gives the same result when different concentrations of the two solutions are used.

9 Zinc strips are inserted into each of four beakers containing four different liquids. Each beaker is identified by a single Roman numeral.

The following observations were made.

Beaker	Initial Observation	Conductivity before zinc is added
I	no visible reaction	very poor
II	bubbles of a colorless gas form on the zinc strip	good
III	bubbles of reddish-brown gas form on the zinc strip	good
IV	no visible reaction	very good

On the basis of the evidence given which one of the following is the most reasonable inference?

A Beakers I and IV contain aqueous solutions of strong acids.

B Beaker II could contain an aqueous acid.

C Beaker III could not contain an aqueous acid.

D Beaker III must contain sulfuric acid, H_2SO_4.

E Beakers I and IV contain alkaline solutions.

10 A hydrocarbon contains only carbon and hydrogen atoms in the ratio 1:2 and has a molecular weight of about 28. Which of the following could probably be the molecular formula of the compound?

(Atomic masses: H = 1, C = 12, N = 14)

A CH_2

B CH_2N

C C_2H_4

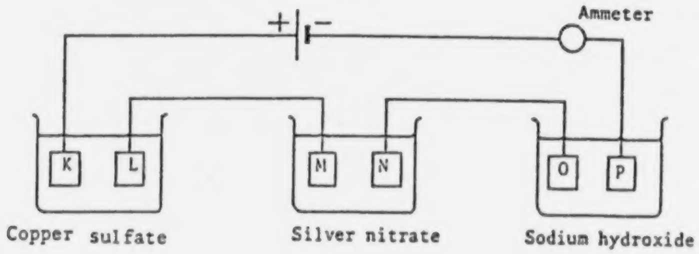
D C_3H_6N

E C_4H_8

11 Which one of the following elements forms an oxide which turns red litmus paper blue when added to water?

A phosphorous
B carbon
C iron
D sulfur
E calcium

12 Copper strips K and L, silver strips M and N and platinum strips O and P, which are equal to each other in surface area and mass, are hung opposite each other in aqueous solutions of copper sulfate, silver nitrate and dilute sodium hydroxide respectively. They are connected in series as the figure shows, and a constant current of 0.5 A (amperes) is sent through for several minutes.



Approximate relative atomic masses:

H = 1 N = 14 O = 16 Na = 23
S = 32 Cu = 63.5 Ag = 108 Pt = 195

Which strip gained most weight?

A copper strip K
B copper strip L
C silver strip M
D silver strip N
E platinum strip P

13 What volume of carbon dioxide is produced by burning 3 g of carbon in excess oxygen?

Assume that the gas volume is measured at STP (0 °C, 1 atmosphere pressure). The relative atomic mass of carbon is 12. The relative atomic mass of oxygen is 16. One mole of any gas occupies 22.4 liter at STP.

A 0.25 liter
B 5.6 liter
C 11.0 liter
D 44.8 liter
E 67.2 liter

14 One kind of stainless steel contains approximately 13 percent chromium and 1 percent nickel by mass; the rest is iron. Which of the following gives the closest approximation to the ratio of the number of chromium atoms to iron atoms in this stainless steel?

The relative atomic mass of chromium = 52. The relative atomic mass of iron = 56.

A $\frac{13}{52} : \frac{14}{56}$

B $\frac{13}{52} : \frac{86}{56}$

C $\frac{13}{108} : \frac{86}{108}$

D $\frac{13}{(100-52)} : \frac{87}{(100-56)}$

E $\frac{13}{100} \times 52 : \frac{86}{100} \times 56$

15 What is the minimum mass of sodium chloride (NaCl) that is needed to prepare 7.1 g of chlorine?

The relative atomic mass of sodium = 23. The relative atomic mass of chlorine = 35.5.

A 5.9 g
B 7.1 g
C 11.7 g
D 12.7 g
E 14.2 g

16 Which of the following elements, when combined with a transition metal, is most likely to cause the transition metal to be in its highest oxidation state?

A iodine
B sulfur
C fluorine
D phosphorus
E hydrogen

17 A 15.0 cm^3 sample of a 1.00 M (mol/liter) solution of hydrochloric acid (HCl) will exactly neutralize 7.5 cm^3 of a 1.00 M solution of which one of the following substances?

A sodium hydrogen carbonate: $NaHCO_3$
B potassium hydroxide: KOH
C ethanol: C_2H_5OH
D barium hydroxide: $Ba(OH)_2$
E magnesium chloride: $MgCl_2$

18 A chemist working for a toothpaste firm wishes to prepare 250 cm^3 of a 0.010 M (mol/liter) aqueous solution of tin (II) fluoride. Fortunately for her, tin (II) fluoride is soluble in water. One mole of tin (II) fluoride weighs 156.7 g. Equipment available includes a 250 cm^3 volumetric flask, a 10 cm^3 pipette, a 0.01 g sensitivity balance, and a 400 cm^3 beaker.

Once the appropriate amount of tin (II) fluoride has been weighed, which one of the following procedures would be best?

A Place the tin (II) fluoride in the beaker and add exactly 250 cm^3 of water from the volumetric flask.

B Place the tin (II) fluoride in the beaker and add exactly 250 cm^3 of water from the pipette in 10 cm^3 portions.

C Place the tin (II) fluoride in the volumetric flask, dissolve it in less than 250 cm^3 of water, and then dilute to the 250 cm^3 mark.

D Using the beaker and balance, weigh out exactly 250 g of water and add the tin (II) fluoride to it.

E Dissolve the tin (II) fluoride in more than 250 cm^3 of water in the beaker and then fill the volumetric flask to the line with the solution.

19 Which of the following would be described best as an oxide could only be basic?

A Al_2O_3

B CO

C P_2O_5

D NO_2

E CaO

20 Selenium (Se) is the element below sulfur in the same group of the periodic table. Which one of the following characteristics would you expect selenium to possess?

A to be a metal with a high boiling point

B to form a potassium oxy-salt of formula K_3SeO_4

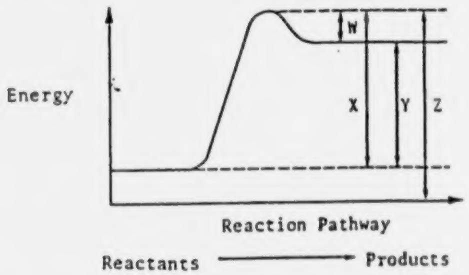
C to burn in air to form an oxide SeO

D to dissolve in nitric acid to form a salt $Se(NO_3)_4$

E to form a compound H_2Se which is weakly acidic in aqueous solution

21 The following energy diagram refers to the reaction:

$Br + H_2 \longrightarrow HBr + H.$



Which vertical distance represents the heat of reaction?

A W

B X

C Y

D Z

E Z minus W

22 A certain reaction does not take place in the dark but proceeds explosively as soon as it is exposed to light. Which of the following is the best explanation of this observation?

A Light provides the energy which is released as heat in the explosion.

B Light initiates the reaction which then proceeds very rapidly.

C Light acts as a catalyst, being regenerated during the explosion.

D Light heats the unstable reactant(s) which then explode.

E The total reaction is endothermic and light initiates it by supplying much more than the required energy.

23 The rate of reaction of two substances X and Y is measured at different concentrations of X and Y as shown in the table.

Rate of Reaction (mol/liter-sec)	Concentration X (mol/liter)	Concentration Y (mol/liter)
12×10^{-3}	5	5
36×10^{-3}	15	5
24×10^{-3}	10	10

Which one of the following statements describes the rate of reaction?

A It is proportional to the concentration of X but independent of the concentration of Y.

B It is proportional to the concentrations of X and Y.

C It is proportional to the concentration of Y but independent of the concentration of X.

D It is dependent on the concentrations of X and Y but not satisfactorily expressed in A, B, or C.

E It is dependent on some unspecified factors other than concentration.

24 A mixture of nitrogen, hydrogen and ammonia gases reach equilibrium in a thermally insulated stainless steel container.

The equilibrium is symbolized by the following equation, in which the reaction to the right is exothermic:

$$N_2 + 3H_2 \rightleftarrows 2NH_3 + \text{heat}$$

Which of the following is the best description of the effect of increasing the concentration of hydrogen and allowing a new equilibrium to be reached?

A There is a decrease in the yield of ammonia but no rise in temperature.

B There is a decrease in the yield of ammonia and a rise in temperature.

C There is an increase in the yield of ammonia but no rise in temperature.

D There is an increase in the yield of ammonia and a rise in temperature.

E The equilibrium concentrations remain unchanged.

25 The following equation represents an equilibrium reaction in a closed container:

$$2CO + O_2 \rightleftharpoons 2CO_2$$

The heat of reaction (ΔH) = -585 kj/mol indicating that the reaction is exothermic.

Which one of the following disturbances will produce a greater equilibrium yield of carbon dioxide?

- A raising the temperature and pressure
- B lowering the temperature and pressure
- C raising the temperature and lowering the pressure
- D lowering the temperature and raising the pressure
- E adding a catalyst and lowering the pressure

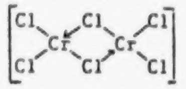
26 When alcohol is burned in air, water is formed. Another product of the combustion is a gas which turns lime water cloudy. Consider the following three statements with regard to these two facts.

- I Carbon is a constituent element of alcohol.
- II Hydrogen is a constituent element of alcohol.
- III Oxygen is a constituent element of alcohol.

Which statement or combination of these statements can be deduced from the two facts given?

- A I and II
- B I, II and III
- C I and III
- D II and III
- E I only

27 Chromic chloride hexahydrate has the empirical formula $CrCl_3.6H_2O$. It exists in several isometric forms. When one of these isomers is allowed to react with excess of silver nitrate in aqueous solution, 2 mol of silver chloride are precipitated for every 1 mol of the chromium salt. Which one of the following represents most accurately the ionic dissociation of the salt?

- A $Cr(H_2O)_6^{3+} + 3Cl^-$
- B $CrCl_3(H_2O)_3 + 3H_2O$
- C $(CrCl\ (H_2O)_5)^{2+} + 2Cl^- + H_2O$
- D $(CrCl_2(H_2O)_4)^+ + Cl^- + 2H_2O$
- E  + $12H_2O$

28 How is the presence of ions in an aqueous (water) solution of a substance most directly detected?

A by measuring its electrical conductivity

B by measuring the density of the solution and comparing it with those of the pure solute and water

C by checking if the solution has an electric charge

D by evaporating the solution and testing the residue for conductivity

E by adding an ionic substance and seeing if there is a reaction

29 The half life of the radioactive isotope potassium ^{42}K is 12.4 hours. What is the estimated time to reduce the activity of a sample to about 3 percent of its original value?

A about 12.4 hours

B about 37 hours

C about 50 hours

D about 62 hours

E about 124 hours

30 An atom of a radioactive element first emits an alpha particle and then emits a beta particle. What happens to the nuclear charge?

A It decreases by 1 unit.

B It increases by 1 unit.

C It decreases by 2 units.

D It decreases by 3 units.

E It decreases by 4 units.

SISS-U.S. Advanced Physics

International Science Study

Second Year Physics

Booklet 1

Supported by
National Science Foundation

Conducted by
Columbia University
Research Triangle Institute

The Second International Science Study is being conducted with the support of the National Science Foundation. While you are not required to respond, your cooperation is needed to make the results of this study comprehensive, accurate, and timely. All information that would permit identification of an individual, a school, or a school district will be held in strict confidence.

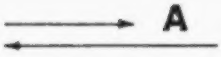
INSTRUCTIONS

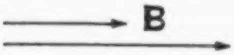
This test contains questions about physics. Each of the questions is followed by five suggested answers, shown by the letters A, B, C, D, and E. For each question you must choose the one answer you think is correct. In the section of the Answer Sheet headed SCIENCE TEST-BOOKLET 1, darken the circle for the appropriate letter.

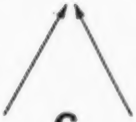
If you do not know the answer to a question, leave it and go on to the next question. You can come back to this question later. You may answer questions even if you are not sure, but do not guess blindly.

You will have 45 minutes to complete the booklet. Please do not begin until you are told to do so.

1 Which two vectors shown have the resultant represented by $\longrightarrow$?


A


B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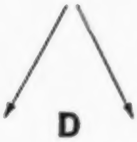
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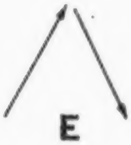

E

2 Which of the following statements involves vector quantities only?

A Gravitational field strength is 9.8 N/kg.

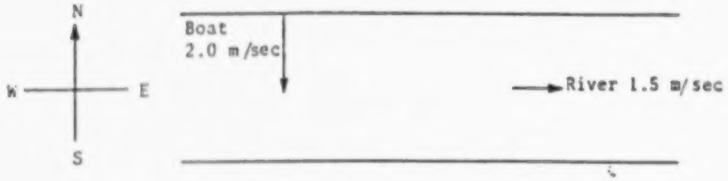
B Each solid body has weight and inertial mass.

C Water freezes at 273 $^{\circ}$K and boils at 373 $^{\circ}$K.

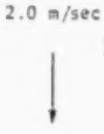
D The charge on an electron is: $3 = 1.6 \times 10^{-19}$ C.

E The kinetic energy of a free falling body is equal to the difference between its potential energy at the start and at the end.

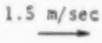
3 A river flows due East at 1.5 m/sec. A motor boat leaves the North bank and heads due South at 2.0 m/sec.


N
W
E
S
Boat
2.0 m/sec
River 1.5 m/sec

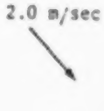
Which of the vectors below best represents the velocity of the boat relative to the river bank?



A



B



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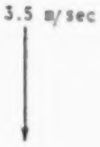
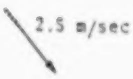


D



E

4 A stone is dropped from rest down a deep well. It takes 2 sec to reach the bottom. How deep is the well?

Assume that the air resistance of the falling stone is negligible and that the acceleration due to gravity $g = 9.8\ m/sec^2$.

A 4.9 m

B 9.8 m

C 19.6 m

D 39.2 m

E 78.4 m

5 Car A moving in a straight line at a constant velocity of 20 m/sec is initially 200 m behind Car B moving in the same straight line at a constant velocity of 15 m/sec. How far must Car A travel from this initial position before it catches up with Car B?

A 200 m

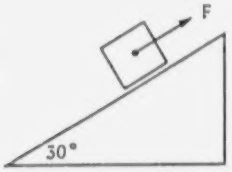
B 400 m

C 600 m

D 800 m

E 1000 m

6 Object mass = 10 kg



Some of this information may be useful:

$\sin 30^\circ = 0.50$ $\sin 60^\circ = 0.87$
$\cos 30^\circ = 0.87$ $\cos 60^\circ = 0.50$

Acceleration due to gravity $g = 9.8\ \text{m/sec}^2$

An object of mass 10 kg is to be held at rest on a flat surface which is inclined at 30° to the horizontal. Assume that there are no frictional forces between the object and the inclined surface. What is the value of the minimum force F acting parallel to the surface which is needed to prevent the object from sliding down the inclined surface?

A 10 N

B 49 N

C 85 N

D 98 N

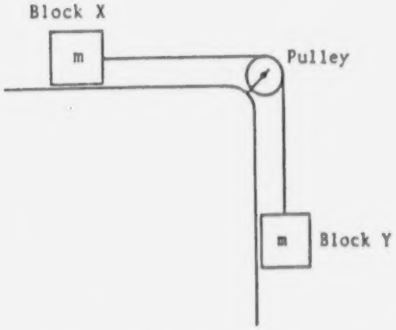
E 196 N

7 Ball A of mass 5 kg moving at 20 m/sec collides with Ball B of unknown mass moving at 10 m/sec in the same direction. After collision, Ball A moves at 10 m/sec and Ball B at 15 m/sec, both still in the same direction.

What is the mass of Ball B?

A 2 kg
B 6 kg
C 10 kg
D 12 kg
E 30 kg

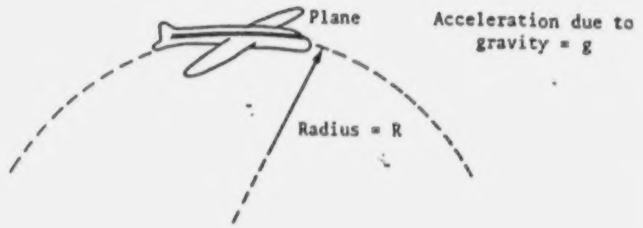
8



A rope is attached to two blocks of equal mass m as shown in the diagram. Block X is initially held at rest on a flat horizontal frictionless surface, and the rope passes over a pulley. When Block X is released, what is the acceleration of Block Y?

A zero
B $g/2$
C g
D $\sqrt{2}\, g$
E $2g$

9



An aircraft flies in a vertical circular path of radius R at a constant speed. When the aircraft is at the top of the circular path the passengers feel "weightless". What is the tangential speed of the aircraft?

A gR

B $\sqrt{gR}$

C g/R

D $\sqrt{g/R}$

E $2gR$

10 A stone is thrown upward at an angle of 45°. At the highest point reached by the stone, which one of the following is true?

A Acceleration is zero.

B Acceleration is at a minimum, but not zero.

C Total energy is at a maximum.

D Potential energy is at a minimum.

E Kinetic energy is at a minimum.

11 The figure shows the respective positions which a small ball occupied every 1/7 second after it had been shot up vertically by a spring. Assume that the spring is compressed to the point X and then released, and that the ball leaves the spring at Y. The highest position that the ball reaches is Z. Assume that air resistance is negligible and that the acceleration due to gravity is 9.8 m/sec^2.

What is the acceleration of the ball at the position Y?

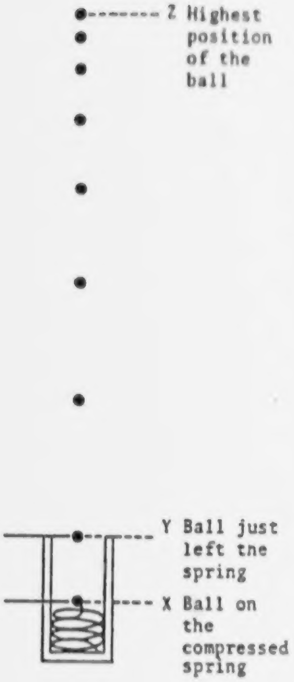
A zero

B less than 9.8 m/sec^2

C 9.8 m/sec^2

D greater than 9.8 m/sec^2

E It is impossible to say unless the height the ball rises is given.


Z Highest position of the ball
Y Ball just left the spring
X Ball on the compressed spring

12 A car with a mass of 100 kg is moving with a constant velocity of 4 m/sec. What is its kinetic energy?

A 200 joules

B 400 joules

C 800 joules

D 1600 joules

E 20000 joules

13 In an imaginary situation, a 1 kg block of ice at 0 °C is dropped from such a height that all of it is melted by the heat generated on impact with the ground. From what height would a 25 kg block of ice have to be dropped to melt completely? Assume that in both cases all of the heat produced is absorbed by the ice.

A 1/5 as high

B 1/25 as high

C the same height

D 5 times as high

E 25 times as high

14 A 1500 watt electric water heater can heat 2 kg of water from 15 °C to 35 °C in 140 seconds. Find the efficiency of the heater. Assume that 4200 joules of heat energy are needed to increase the temperature of 1 kg of water by 1 °C.

A 20 percent

B 40 percent

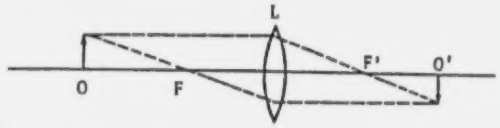
C 80 percent

D 100 percent

E 125 percent

15 The three Diagrams 1, 2, 3, give the graphical construction for image O' of object O as produced by the thin lens L with foci F and F'.

1



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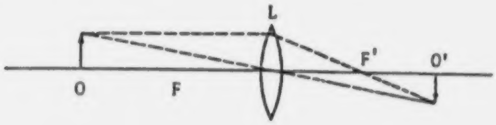

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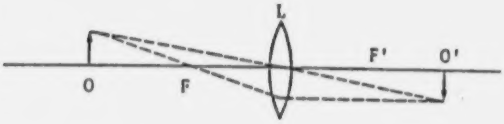
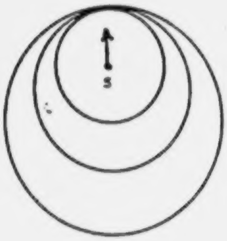


Which, if any, of these three diagrams are correct?

- A Only Diagrams 2 and 3 are correct.
- B Only Diagrams 1 and 3 are correct.
- C Only Diagrams 1 and 2 are correct.
- D None of the diagrams is correct.
- E All three diagrams are correct.

16 The sketch shows the pattern of circular waves produced by a moving source S in a tank of water. Sound can be described as a wave motion and that the pitch of a particular sound becomes higher with an increase in frequency. Which of the following phenomena might be predicted from this pattern?



A The intensity of sound from a moving source varies inversely as the source of the square of the distance from the source.

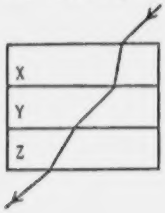
B The pitch of a musical note from a vibrating string varies with the tension of the string.

C The sound of a passing automobile horn to an observer by the side of a road drops in pitch as the car passes.

D The velocity of propagation of sound waves increases without a change in pitch as the sound passes into a denser medium.

E The second harmonic is equal to twice the fundamental frequency.

17 A ray of blue light passes through a stack of three parallel-sided blocks made of different materials. The path of the beam is shown. In which of the three blocks is the velocity of blue light greatest?



A X

B Y

C Z

D The velocity is the same in all the blocks.

E The information given is insufficient to be able to say.

18 Hertz detected radiations by means of a spark detector. When he placed his receiver between the source of radiation and a metal sheet, he found that the strongest sparks resulted at multiples of a certain distance from the reflecting sheet. Which one of the following can be concluded from this experiment about the nature of the radiations?

A They consisted of transverse waves.

B They consisted of longitudinal waves.

C They consisted of waves, but gives no indication as to whether they are transverse or longitudinal.

D They consisted of ultrasonic radiation.

E They consisted of some form of energy moving through air with the speed of light.

19 In the spectrum of the sun a continuous spectrum is crossed by many black lines (Fraunhofer lines). Which of the following statements is correct?

A The black lines are caused by Fraunhofer diffraction at the telescope.

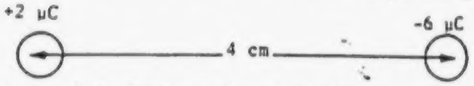
B The black lines are caused by the absorption of light by the gases of the Sun's atmosphere.

C The spectrum of the Sun lacks the spectral lines of all the elements present in the Sun.

D The black lines come from the combustion of elements at the Sun.

E The spectrum of the Sun is changed in the space between Sun and Earth by cosmic radiation.

20 Two small charges of +2 µC (micro-coulombs) and -6 µC respectively are placed 4 cm apart as shown. Where should a third charge -8 µC be placed so that there is no net force on the -6 µC charge?



A 4 cm left of the -6 µC charge

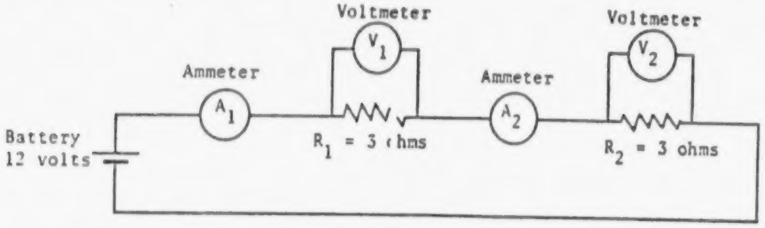
B 16 cm left of the -6 µC charge

C 16 cm right of the -6 µC charge

D 8 cm left of the -6 µC charge

E 8 cm right of the -6 µC charge

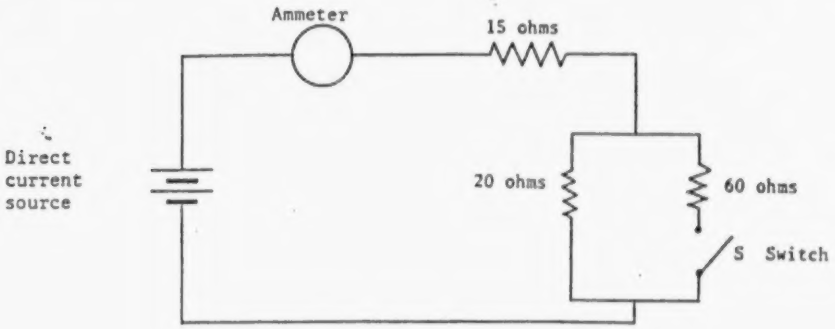
21 This question is based on the circuit represented by the diagram below.


Voltmeter
V_1
Voltmeter
V_2
Ammeter
A_1
Ammeter
A_2
Battery
12 volts
R_1 = 3 ohms
R_2 = 3 ohms

Which one of the following sets of results would be observed?

Set	Ammeter A_1	Voltmeter V_1	Ammeter A_2	Voltmeter V_2
A	1 amp	6 volts	1 amp	6 volts
B	1 amp	12 volts	1 amp	12 volts
C	1 amp	6 volts	2 amps	12 volts
D	2 amps	6 volts	2 amps	6 volts
E	2 amps	12 volts	2 amps	12 volts

22 The following diagram represents an electric circuit.



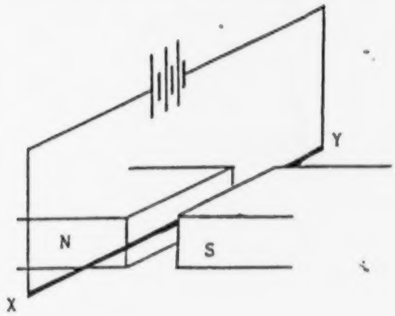
When the switch S is open the reading on the ammeter A is 2.0 amperes. When the switch is closed, what happens to the reading on the ammeter?

- A It would halve.
- B It would decrease slightly.
- C It would remain the same.
- D It would increase slightly.
- E It would double.

23 Under which of the following circumstances is an electromotive force (EMF) not induced in a conductor in a uniform magnetic field?

- A The magnetic field is moving at right angles to the conductor.
- B The conductor is moving at right angles to the magnetic field.
- C The magnetic field and the conductor are relatively stationary, but the magnetic field is increasing.
- D The conductor is moving parallel to the magnetic field.
- E The magnetic field and the conductor are stationary relative to each other, but the magnetic field is dying away to zero.

24 A wire with an electric current passing through it is placed in a magnetic field as shown in the diagram.



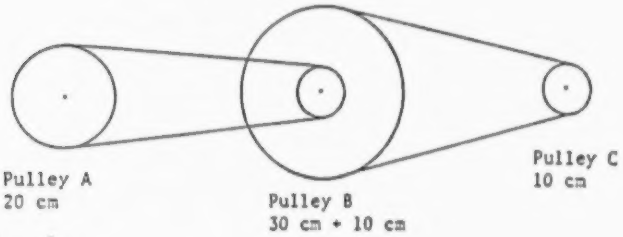
In which direction will the wire move?

- A towards the North pole
- B towards the South pole
- C vertically up
- D vertically down
- E in the direction of point Y

25 What happens when a photon collides with a free electron?

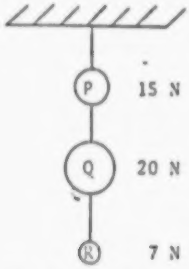
- A Energy is conserved; momentum is not.
- B Momentum is conserved; energy is not.
- C Both energy and momentum are conserved.
- D Neither energy nor momentum need be conserved.
- E Momentum is conserved; the nature of the collision determines whether energy is conserved.

26 The diagram below shows a system of pulley wheels linked by belts. Pulley A has a diameter of 20 cm. Pulley B consists of a large pulley of diameter 30 cm and a small pulley of 10 cm fixed together. Pulley C has a diameter of 10 cm. If Pulley A is turned through one complete revolution, how many revolutions are made by Pulley C?


Pulley A
20 cm
Pulley B
30 cm + 10 cm
Pulley C
10 cm

A 5
B 6
C 12
D 13
E 36

27 The objects P, Q and R of weight 15 N (newtons), 20 N and 7 N, are hung with a light thread as shown in the figure.


P
15 N
Q
20 N
R
7 N

What is the tension in the thread between P and Q?

A 42 N

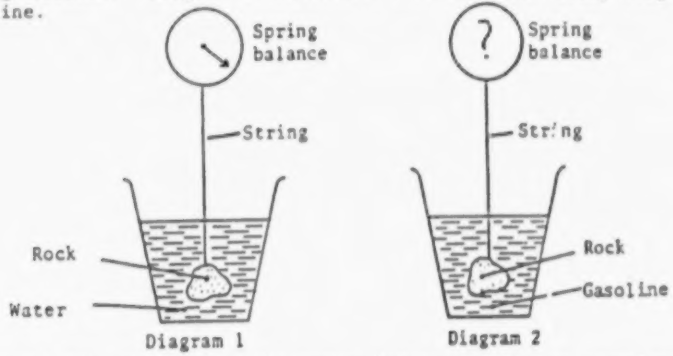
B 35 N

C 27 N

D 15 N

E 7 N

28 Diagram 1 represents a rock suspended in water being weighed using a spring balance. Diagram 2 represents the same rock being weighed in gasoline.


Spring balance
String
Rock
Water
Diagram 1
?
Spring balance
String
Rock
Gasoline
Diagram 2

How would the readings of the spring balance on the two occasions compare?

A The reading of the spring balance in Diagram 1 would be greater than the reading in Diagram 2.

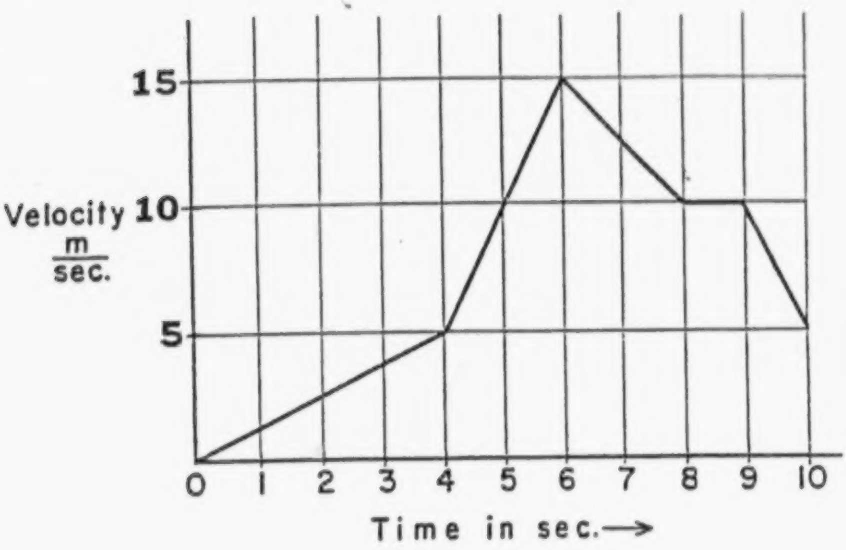
B The reading of the spring balance in Diagram 1 would be the same as the reading in Diagram 2.

C The reading of the spring balance in Diagram 1 would be less than the reading in Diagram 2.

D It would depend on the type of rock.

E It would depend on the air pressure.

29 Base your answer to this question on the graph below which represents a velocity versus time graph for an object moving in a straight line.



During which time interval did the object travel the greatest distance?

A 0 sec to 4 sec
B 4 sec to 6 sec
C 6 sec to 8 sec
D 8 sec to 9 sec
E 9 sec to 10 sec

30 An atom with atomic number Z and atomic mass (mass number) W changes into one with atomic number Z + 1 and atomic mass W. Which of the following nuclear changes could have taken place?

- A the emission of an alpha particle
- B the emission of a beta particle
- C the emission of gamma rays
- D the absorption of a deuteron and then emission of a neutron
- E the absorption of a neutron and the emission of a gamma photon

APPENDIX F

SISS-U.S. ADVANCED SCIENCE OPPORTUNITY-TO-LEARN RATINGS

U.S. Advanced Science Test Items: Opportunity-to-Learn Ratings; Percent of Teachers Indicating Opportunity to Learn Content Either in Current Year's Course or in a Previous Year's Course by Subject Area

	U.S. Advanced Science Test					
	Biology		Chemistry		Physics	
Test Item	Current Course	Previous Course	Current Course	Previous Course	Current Course	Previous Course
1	53.4	38.4	61.5	35.2	50.1	49.9
2	52.4	32.6	31.1	46.8	53.5	46.5
3	32.3	49.2	60.5	39.5	56.4	43.6
4	42.8	47.3	36.0	51.3	45.5	54.5
5	48.3	43.6	1.2	53.1	27.5	72.5
6	39.6	45.4	69.0	29.2	30.5	69.5
7	42.4	42.3	39.2	59.0	34.5	65.5
8	27.7	53.5	51.4	48.6	24.8	75.2
9	38.6	46.1	43.5	33.4	29.1	70.9
10	51.5	48.5	69.4	30.6	35.3	64.7
11	22.7	64.4	46.7	44.7	26.9	73.1
12	40.3	36.8	5.7	32.6	52.7	47.3
13	54.4	35.2	69.4	30.6	43.5	44.5
14	14.1	40.8	61.3	31.8	44.7	42.8
15	13.6	45.3	76.3	23.7	48.1	39.9
16	21.9	43.4	27.4	42.7	42.0	53.3
17	30.7	40.5	37.8	48.0	43.2	52.9
18	14.6	50.3	30.2	63.1	25.3	28.1
19	14.6	22.6	42.2	43.0	27.6	40.6
20	34.1	37.0	55.7	38.1	21.3	68.5
21	26.6	37.5	28.8	37.6	35.8	53.3
22	28.6	43.1	34.8	44.5	35.1	53.9
23	57.0	34.9	13.9	47.6	20.2	60.9
24	44.4	45.6	31.8	51.5	28.1	57.0
25	16.9	50.5	15.2	68.0	25.3	44.0
26	26.5	40.8	59.1	38.3	31.0	32.8
27	60.1	34.0	9.5	45.0	27.3	66.6
28	46.3	42.0	42.7	42.7	36.9	41.9
29	45.6	40.8	26.0	34.1	49.1	50.9
30	35.5	31.4	24.8	33.6	37.7	38.0

Correlation coefficients for Opportunity-to-learn rating of "This year's course OR previous year's course" with student achievement scores on all 30 test items:

Achievement Scores	Correlation Coefficicent
Advanced Biology	+ .19
Advanced Chemistry	+ .47
Advanced Physics	- .35

APPENDIX G

SISS-U.S. ADVANCED SCIENCE QUESTIONNAIRE ITEM RECODES

Item	Recoding
Student Questionnaire Items	
Q02	(1,2 = 0)(3 = 3)(4 = 4)(5 = 5)
Q03	(1,2 = SYSMIS)(3 = 1)(ELSE = 0)
Q04	(1 = 7)(2 = 6)(3 = 5)(4 = 4)(5 = 3) (6 = 2)(7 = 1)(8 = 0)
Q05	(1 = SYSMIS)((2 = 0)(3 = 1)(4 = 4) (5 = 8)(6 = 15)(7 = 21)
Q06	(1 = SYSMIS)(2 = 0)(3 = 1)(4 = 5)(5 = 8)(6 = 11)
Q07	(1 = 8)(2 = 7)(3 = 6)(4 = 5)(5 = 4) (6 = 3)(7 = 2)(8 = 1)
Q08, Q09	(1 = 1)(2 = 0)
Q10	(1 = 0)(2 = 1)(3 = 3)(4 = 8)(5 = 11)
Q11	(1 = 0)(2 = 1)(3 = 2)(4 = 3)(5 = 4)(6 = 5)
Q12, Q14	(1 = SYSMIS)(2 = 8)(3 = 10)(4 = 12) (5 = 14)(6 = 16)(7 = SYSMIS)
Q13, Q15	(1 = SYSMIS)(2 = 1)(3 = 2)(4 = 3)(5 = 4) (6, 7 = SYSMIS)
Q16	(1 = 5)(2 = 13)(3 = 63)(4 = 175)(5 = 375) (6 = 575)
Student Description of Science Learning	
D01 to D24	(1 = 3)(2 = 1)(3 = 0)
Student Opinionnaire	
A01, A02, A04, A05, A07, A08, A10, A11, A13, A16, A17, A21 TO A23	(1 = 3)(2 = 1)(3 = 2)

Item	Recoding
Teacher Questionnaire	
TQ01	(1 = 27)(2 = 33)(3 = 43)(4 = 53)(5 = 58)
TQ02	(1 = 0)(2 = 2)(3 = 3)(4 = 5)(5 = 7)
TQ03	(1 = SYSMIS)(2 = 0)(3 = 25)(4 = 38)(5 = 51)
TQ04	(1 = 5)(92 = 8)(3 = 15)(4 = 25)(5 = 31)
TQ05, TQ07, TQ10, TQ12	(1 = 1)(2 = 0)
TQ08	(1 = 15)(2 = 18)(3 = 23)(4 = 28)(5 = 31)
TQ09, TQ11	(1 = 4)(2 = 3)(3 = 1)(4 = 0)
TQ13, TQ14	(1 = 4)(2 = 3)(3 = 2)(4 = 0)
TQ15	(1 = 0)(2 = 1)(3 = 2)(4 = 4)(5 = 6)
TQ16	(1 = 0)(2 = 20)(3 = 50)(4 = 70)(5 = 90)
TQ17	(1 = 3)(2 = 5)(3 = 8)(4 = 13)(5 = 16)
TQ18 to TQ21	(1 = 4)(2 = 8)(3 = 13)(4 = 18)(5 = 21)
TQ22, TQ25 to TQ29	(1 = 5)(2 = 4)(3 = 1)(4 = 0)(5 = SYSMIS)
TQ23, TQ24	(1 = 0)(2 = 1)(3 = 2)(4 = 3)(5 = SYSMIS)
TQ30 to TQ44	(1 = 4)(2 = 3)(3 = 1)(4 = 0)
School Administrator Questionnaire	
AQ01	(1,2 = 1)(3,4 = 0)
AQ02	(1 = 1000)(2 = 550)(3 = 55)(4 = 5)(5 = 1)
AQ04	(1 = 20)(2 = 25)(3 = 35)(4 = 45)(5 = 51)
AQ05	(1 = 20)(2 = 25)(3 = 35)(4 = 45)(5 = 55)
AQ06	(1 = 20)(2 = 23)(3 = 28)(4 = 33)(5 = 37)
AQ07	(1 = 170)(2 = 175)(3 = 185)(4 = 195)(5 = 201)
AQ08, AQ09, AQ12	(1 = 0)(2 = 1)(3 = 2)(4 = 3)(5 = 4)
AQ10	(1 = 0)(2 = 1)(3 = 3)(4 = 7)(5 = 4)
AQ11	(1 = 39)(2 = 50)(3 = 70)(4 = 81)(5 = 0)
AQ13	(1 = 2)(2 = 1)(3 = 0)
AQ14, AQ15	(1 = 1)(2 = 0)

APPENDIX H

FREQUENCY DISTRIBUTION FOR SISS-U.S. ADVANCED SCIENCE STUDENT RESPONSES: QUESTIONNAIRE; OPINIONNAIRE; AND DESCRIPTION OF SCIENCE LEARNING

Q02 Amount of expected further education

	Bio	Chem	Phys	Item Recode
Not decided	61	16	13	0
Not expected	15	3	3	0
1-2 years	39	15	2	3
3-4 years	232	162	107	4
More than 4 yrs	298	344	365	5
Nonresponse	28	22	11	
Responding	645	540	490	
Mean	3.931	4.469	4.614	
SD	1.551	1.007	.943	

Q03 Type of expected postsecondary education

	Bio	Chem	Phys	Item Recode
Not decided	60	38	38	SystemMissing
Not expected	17	2	0	SystemMissing
Sci/appld sci	270	350	333	1
Soc sci	63	36	27	0
Business/commerc	92	44	52	0
Educ/tchr trning	24	15	3	0
Art/design/music	26	14	11	0
Agriculture	15	6	2	0
English/frgn lang	26	17	12	0
Other	42	12	6	0
Nonresponse	39	29	15	
Responding	635	534	484	
Mean	.453	.670	.721	
SD	.498	.471	.449	

Q04 Amount of television watched per week

	Bio	Chem	Phys	Item Recode
Don't watch in wk	27	19	29	7
Some, <1 hour	75	79	81	6
About 1 hour	90	84	105	5
About 2 hours	135	110	97	4
About 3 hours	132	100	64	3
About 4 hours	83	55	44	2
About 5 hours	40	36	26	1
6 hours or more	64	57	43	0
Nonresponse	30	22	11	
Responding	646	540	489	
Mean	3.836	3.958	2.729	
SD	1.574	1.586	1.592	

Q05 Amount of time spent per week on all homework

	Bio	Chem	Phys	Item Recode
None assigned	6	4	0	SystemMissing
Have but don't do	37	29	20	0
Up to 2 hours	184	126	81	1
Bet 2-5 hours	211	148	100	4
Bet 5-10 hours	132	117	138	8
Betw 10-20 hours	66	95	118	15
More than 20 hrs	8	22	31	21
Nonresponse	28	22	12	
Responding	644	541	488	
Mean	5.086	6.593	8.200	
SD	4.688	5.755	6.050	

Q06 Amount of time spent per week on science homework

	Bio	Chem	Phys	Item Recode
None assigned	51	43	13	SystemMissing
have but don't do	56	53	41	0
Up to 2 hours	364	249	235	1
Bet 2-5 hours	130	139	153	4
Bet 5-10 hours	40	43	32	8
More than 10 hrs	4	13	15	11
Nonresponse	29	22	11	
Responding	645	540	489	
Mean	2.093	2.605	2.666	
SD	2.196	2.642	2.583	

Q07 Description of grades received in school

	Bio	Chem	Phys	Item Recode
Mostly A	122	207	209	8
About half A+B	159	158	150	7
Mostly B	146	101	94	6
About half B+C	131	43	28	5
Mostly C	57	24	5	4
About half C+D	25	8	3	3
Mostly D	5	0	0	2
Mostly below D	0	0	0	1
Nonresponse	9	22	11	
Responding	645	541	489	
Mean	6.097	6.848	7.065	
SD	1.425	1.223	1.017	

Q08 Have own calculator

	Bio	Chem	Phys	Item Recode
YES	451	511	477	1
NO	193	28	12	0
Nonresponse	30	24	11	
Responding	644	539	489	
Mean	.701	.948	.976	
SD	.458	.221	.153	

Q09 Have computers at school

	Bio	Chem	Phys	Item Recode
YES	636	539	489	1
NO	9	2	0	0
Nonresponse	28	22	11	
Responding	645	541	489	
Mean	.986	.997	1.000	
SD	.119	.056	.000	

Q10 Frequency of using computer at school

	Bio	Chem	Phys	Item Recode
NeverUseAtSchool	399	311	200	0
Up to 2 hrs	111	106	114	1
Betw 2-5 hours	97	77	100	3
Betw 5-10 hours	30	31	50	8
More than 10 hrs	9	15	26	11
Nonresponse	28	22	12	
Responding	646	540	490	
Mean	1.147	1.390	2.234	
SD	2.209	2.574	3.151	

Q11 Years of mathematics studied since 8th grade

	Bio	Chem	Phys	Item Recode
None	0	0	0	0
One	7	0	0	1
Two	157	24	3	2
Three	256	217	56	3
Four	174	242	301	4
More than four	52	57	128	5
Nonresponse	28	22	11	
Responding	646	540	488	
Mean	3.168	3.614	4.130	
SD	.922	.734	.629	

Q12 Male guardian's education

	Bio	Chem	Phys	Item Recode
NotLivew/father	18	14	3	SystemMissing
Grade school	14	12	8	8
Some high school	38	25	19	10
High school	143	114	61	12
SomeEdAftrHS	100	102	69	14
College or higher	308	264	323	16
I don't know	20	10	6	SystemMissing
Nonresponse	32	22	11	
Responding	641	541	489	
Mean	14.135	14.249	14.837	
SD	2.256	2.112	1.929	

Q13 Male guardian's occupation

	Bio	Chem	Phys	Item Recode
NotLivew/Father	29	28	9	SystemMissing
Semiskilled	92	58	29	1
Skilled	134	132	91	2
Clerical/sales	53	58	35	3
Prof/executive	278	240	309	4
Homemaker	0	1	1	SystemMissing
Some other	51	23	15	SystemMissing
Nonresponse	36	22	11	
Responding	637	540	489	
Mean	2.916	2.982	3.345	
SD	1.194	1.114	.998	

Q14 Female guardian's education

	Bio	Chem	Phys	Item Recode
NotLivew/mother	4	7	0	SystemMissing
Grade school	7	14	9	8
Some high school	49	21	10	10
High school	197	151	103	12
SomeEdAftrHS	129	109	83	14
College or higher	239	229	275	16
I don't know	19	10	8	SystemMissing
Nonresponse	30	22	11	
Responding	644	541	488	
Mean	13.753	13.984	14.512	
SD	2.102	2.116	1.984	

Q15 Female guardian's occupation

	Bio	Chem	Phys	Item Recode
NotLivew/Mother	9	13	4	SystemMissing
Semiskilled	91	54	42	1
Skilled	47	40	43	2
Clerical/sales	145	121	100	3
Prof/executive	165	140	174	4
Homemaker	155	149	110	SystemMissing
Some other	33	24	16	SystemMissing
Nonresponse	30	22	11	
Responding	645	541	489	
Mean	2.853	2.975	3.133	
SD	1.131	1.058	1.027	

Q16 Number of books in the home

	Bio	Chem	Phys	Item Recode
None(1-10)	9	8	5	5
Few(11-25)	29	18	9	13
Abt1Bkcs(26-100)	150	96	67	63
Abt2Bkc(101-250)	189	142	120	175
Abt3-4Bk(251-500)	173	166	148	375
Rafl/libry(>500)	95	108	138	575
Nonresponse	30	22	12	
Responding	645	538	487	
Mean	251.880	288.623	329.149	
SD	181.326	187.569	190.624	

D01 We use a textbook during science lessons.

	Bio	Chem	Phys	Item Recodes
OFTEN	285	270	273	3
SOMETIMES	319	226	182	1
NEVER	37	43	34	0
Nonresponding	32	23	11	
Responding	641	539	489	
Mean	1.831	1.919	2.047	
SD	1.071	1.112	1.100	

D02 When I have science homework, I hand it in on time.

	Bio	Chem	Phys	Item Recodes
OFTEN	437	396	338	3
SOMETIMES	193	127	129	1
NEVER	13	16	21	0
Nonresponding	30	23	12	
Responding	643	539	488	
Mean	2.340	2.442	2.344	
SD	.972	.945	1.005	

D03 At the start of each science lesson, the teacher reminds class about work we covered during the previous lessons.

	Bio	Chem	Phys	Item Recodes
OFTEN	261	205	169	3
SOMETIMES	321	286	266	1
NEVER	59	49	54	0
Nonresponding	33	23	11	
Responding	641	540	489	
Mean	1.722	1.668	1.582	
SD	1.096	1.079	1.076	

D04 At the start of each science lesson, the teacher explains the work we have to cover during the lesson.

	Bio	Chem	Phys	Item Recodes
OFTEN	318	232	231	3
SOMETIMES	261	243	207	1
NEVER	64	63	48	0
Nonresponding	31	23	13	
Responding	643	538	486	
Mean	1.889	1.744	1.852	
SD	1.135	1.135	1.131	

D05 At end of each science lesson, the teacher gives a summary of of what was taught in the lesson.

	Bio	Chem	Phys	Item Recodes
OFTEN	160	127	133	3
SOMETIMES	329	284	258	1
NEVER	154	128	96	0
Nonresponding	30	23	12	
Responding	643	539	487	
Mean	1.257	1.235	1.348	
SD	1.082	1.062	1.082	

D06 When I sit down to do my science homework, I start right away.

	Bio	Chem	Phys	Item Recodes
OFTEN	147	144	140	3
SOMETIMES	350	285	242	1
NEVER	147	111	103	0
Nonresponding	30	23	15	
Responding	644	540	485	
Mean	1.227	1.327	1.365	
SD	1.044	1.080	1.113	

D07 The teacher uses our ideas/suggestions when planning science lessons.

	Bio	Chem	Phys	Item Recodes
OFTEN	86	77	71	3
SOMETIMES	320	258	261	1
NEVER	237	202	147	0
Nonresponding	30	25	21	
Responding	643	537	479	
Mean	.900	.910	.992	
SD	.947	.971	.951	

D08 The teacher does demonstrations to help explain scientific ideas.

	Bio	Chem	Phys	Item Recodes
OFTEN	268	257	276	3
SOMETIMES	307	250	199	1
NEVER	68	32	10	0
Nonresponding	30	23	14	
Responding	643	539	485	
Mean	1.728	1.896	2.116	
SD	1.117	1.080	1.025	

D09 The teacher makes science lessons interesting for us.

	Bio	Chem	Phys	Item Recodes
OFTEN	232	209	188	3
SOMETIMES	344	268	258	1
NEVER	66	63	40	0
Nonresponding	32	23	14	
Responding	642	540	486	
Mean	1.620	1.657	1.690	
SD	1.080	1.111	1.074	

D10 When I do my science homework, I am distracted by things going on around me.

	Bio	Chem	Phys	Item Recodes
OFTEN	170	106	96	3
SOMETIMES	382	355	289	1
NEVER	91	78	100	0
Nonresponding	30	23	15	
Responding	643	539	485	
Mean	1.388	1.247	1.191	
SD	1.025	.933	.983	

D11 For science homework, we write up reports of our laboratory project work.

	Bio	Chem	Phys	Item Recodes'
OFTEN	194	285	200	3
SOMETIMES	274	179	206	1
NEVER	176	75	79	0
Nonresponding	30	23	15	
Responding	644	539	485	
Mean	1.328	1.919	1.663	
SD	1.025	1.189	1.173	

D12 The teacher explains how the science we learn is relevant to our own lives.

	Bio	Chem	Phys	Item Recodes
OFTEN	224	167	168	3
SOMETIMES	322	269	259	1
NEVER	96	103	57	0
Nonresponding	31	23	57	
Responding	642	539	484	
Mean	1.546	1.430	1.579	
SD	1.116	1.117	1.085	

D13 The teacher discusses possible careers in science with us.

	Bio	Chem	Phys	Item Recodes
OFTEN	116	118	56	3
SOMETIMES	336	290	256	1
NEVER	191	132	173	0
Nonresponding	30	23	15	
Responding	643	540	485	
Mean	1.065	1.191	.876	
SD	1.009	1.040	.899	

D14 We have tests on what we have learned in science.

	Bio	Chem	Phys	Item Recodes
OFTEN	586	470	415	3
SOMETIMES	53	60	66	1
NEVER	4	9	4	0
Nonresponding	30	23	15	
Responding	643	539	485	
Mean	2.816	2.725	2.704	
SD	.596	.727	.729	

D15 The science teacher helps students who have difficulties learning science.

	Bio	Chem	Phys	Item Recodes
OFTEN	279	305	255	3
SOMETIMES	296	205	193	1
NEVER	66	29	36	0
Nonresponding	33	24	17	
Responding	641	539	484	
Mean	1.767	2.080	1.980	
SD	1.122	1.075	1.107	

D16 When I have science homework, I attempt to do all of it.

	Bio	Chem	Phys	Item Recodes
OFTEN	382	321	245	3
SOMETIMES	222	189	208	1
NEVER	39	27	31	0
Nonresponding	30	25	16	
Responding	643	537	484	
Mean	2.128	2.144	1.949	
SD	1.081	1.065	1.091	

D17 We do field work outside the classroom as part of our science lessons.

	Bio	Chem	Phys	Item Recodes
OFTEN	60	23	18	3
SOMETIMES	218	103	131	1
NEVER	363	412	335	0
Nonresponding	33	24	16	
Responding	641	538	484	
Mean	.620	.320	.383	
SD	.893	.691	.680	

D18 We do laboratory work as part of our science lessons.

	Bio	Chem	Phys	Item Recodes
OFTEN	310	411	223	3
SOMETIMES	299	125	232	1
NEVER	34	3	30	0
Nonresponding	30	23	15	
Responding	643	539	485	
Mean	1.910	2.521	1.859	
SD	1.074	.863	1.081	

D19 The science class breaks into small groups of students to do laboratory work.

	Bio	Chem	Phys	Item Recodes
OFTEN	433	470	322	3
SOMETIMES	167	64	130	1
NEVER	44	5	34	0
Nonresponding	30	23	15	
Responding	644	539	486	
Mean	2.277	2.732	2.258	
SD	1.063	.704	1.069	

D20 When we do experiments, the teacher gives us instructions about what to do.

	Bio	Chem	Phys	Item Recodes
OFTEN	480	425	366	3
SOMETIMES	121	102	96	1
NEVER	42	13	22	0
Nonresponding	31	23	16	
Responding	643	540	484	
Mean	2.428	2.550	2.467	
SD	1.007	.878	.959	

D21 When we do an experiment, we use a book or other written instructions to show us how to do it.

	Bio	Chem	Phys	Item Recodes
OFTEN	422	454	272	3
SOMETIMES	172	76	159	1
NEVER	47	9	53	0
Nonresponding	33	23	16	
Responding	641	539	484	
Mean	2.244	2.667	2.015	
SD	1.077	.77[illegible]	1.153	

D22 In our laboratory work, we make up our own problems and then the teacher helps us plan experiments to solve them.

	Bio	Chem	Phys	Item Recodes
OFTEN	40	16	18	3
SOMETIMES	141	121	125	1
NEVER	462	402	340	0
Nonresponding	31	23	16	
Responding	643	539	483	
Mean	.404	.314	.370	
SD	.782	.627	.676	

D23 When we do experiments, the teacher gives us problems to solve leaves us to work out our own methods and solutions.

	Bio	Chem	Phys	Item Recodes
OFTEN	132	141	113	3
SOMETIMES	313	264	250	1
NEVER	198	135	120	0
Nonresponding	31	23	17	
Responding	643	540	483	
Mean	1.102	1.272	1.221	
SD	1.058	1.105	1.067	

D24 In our laboratory work, we make up own problems and work out our own methods to investigate the problems.

	Bio	Chem	Phys	Item Recodes
OFTEN	29	15	25	3
SOMETIMES	150	129	115	1
NEVER	463	396	344	0
Nonresponding	32	23	16	
Responding	642	540	484	
Mean	.369	.321	.391	
SD	.711	.619	.738	

A01 Science is useful for solving problems of everyday life.

	Bio	Chem	Phys	Item Recodes
AGREE	439	411	384	3
DISAGREE	94	59	39	1
UNCERTAIN	111	68	65	2
Nonresponse	31	24	12	
Responding	644	538	488	
Mean	2.536	2.656	2.708	
SD	.735	.667	.605	

A02 I find school challenging.

	Bio	Chem	Phys	Item Recodes
AGREE	442	362	322	3
DISAGREE	136	121	105	1
UNCERTAIN	66	57	60	2
Nonresponse	29	22	12	
Responding	644	540	487	
Mean	2.475	2.446	2.444	
SD	.820	.835	.825	

A03 Science has ruined the environment.

	Bio	Chem	Phys	Item Recodes
AGREE	36	47	38	1
DISAGREE	507	409	362	3
UNCERTAIN	99	83	88	2
Nonresponse	32	23	11	
Responding	642	539	488	
Mean	2.735	2.672	2.662	
SD	.554	.628	.617	

A04 Working in a science laboratory would be an interesting way to earn a living.

	Bio	Chem	Phys	Item Recodes
AGREE	317	315	243	3
DISAGREE	188	109	116	1
UNCERTAIN	128	105	126	2
Nonresponse	40	33	15	
Responding	633	529	485	
Mean	2.204	2.390	2.263	
SD	.870	.806	.820	

A05 Science is very important for a country's development.

	Bio	Chem	Phys	Item Recodes
AGREE	589	505	468	3
DISAGREE	12	7	12	1
UNCERTAIN	40	27	9	2
Nonresponse	33	24	11	
Responding	641	539	489	
Mean	2.901	2.926	2.934	
SD	.355	.304	.330	

A06 School is not very enjoyable.

	Bio	Chem	Phys	Item Recodes
AGREE	209	139	104	1
DISAGREE	326	328	282	3
UNCERTAIN	108	73	101	2
Nonresponse	31	22	12	
Responding	643	540	487	
Mean	2.182	2.350	2.367	
SD	.894	.863	.812	

A07 Money spent on science is well worth spending.

	Bio	Chem	Phys	Item Recodes
AGREE	444	411	376	3
DISAGREE	46	13	12	1
UNCERTAIN	153	115	99	2
Nonresponse	31	22	12	
Responding	643	539	487	
Mean	2.620	2.737	2.747	
SD	.615	.494	.490	

A08 In the future, most jobs will require a knowledge of science.

	Bio	Chem	Phys	Item Recodes
AGREE	430	390	327	3
DISAGREE	70	56	68	1
UNCERTAIN	142	93	93	2
Nonresponse	31	23	11	
Responding	642	539	488	
Mean	2.560	2.620	2.532	
SD	.683	.666	.726	

A09 Much of the anxiety in modern society is due to science.

	Bio	Chem	Phys	Item Recodes
AGREE	156	139	112	1
DISAGREE	238	213	238	3
UNCERTAIN	248	185	138	2
Nonresponse	32	24	11	
Responding	642	537	488	
Mean	2.127	2.138	2.259	
SD	.774	.799	.807	

A10 People who understand science are better off in our society.

	Bio	Chem	Phys	Item Recodes
AGREE	283	315	290	3
DISAGREE	161	110	87	1
UNCERTAIN	199	115	111	2
Nonresponse	31	22	12	
Responding	643	540	488	
Mean	2.189	2.380	2.416	
SD	.810	.802	.775	

A11 It is important to know science in order to get a good job.

	Bio	Chem	Phys	Item Recodes
AGREE	139	144	138	3
DISAGREE	368	266	270	1
UNCERTAIN	135	130	81	2
Nonresponse	31	22	11	
Responding	642	540	489	
Mean	1.644	1.774	1.730	
SD	.815	.842	.874	

A12 I am bored most of the time in school.

	Bio	Chem	Phys	Item Recodes
AGREE	236	199	155	1
DISAGREE	327	294	249	3
UNCERTAIN	79	48	85	2
Nonresponse	31	22	11	
Responding	642	541	489	
Mean	2.142	2.176	2.193	
SD	.926	.939	.889	

A13 Scientific inventions improve our standard of living.

	Bio	Chem	Phys	Item Recodes
AGREE	576	505	450	3
DISAGREE	18	6	9	1
UNCERTAIN	49	29	29	2
Nonresponse	31	22	12	
Responding	643	540	488	
Mean	2.867	2.925	2.906	
SD	.415	.302	.347	

A14 There are many school subjects I don't like.

	Bio	Chem	Phys	Item Recodes
AGREE	284	204	173	1
DISAGREE	305	299	270	3
UNCERTAIN	54	38	45	2
Nonresponse	31	22	11	
Responding	643	541	488	
Mean	2.032	2.177	2.200	
SD	.957	.949	.932	

A15 Scientific inventions have increased tensions between people.

	Bio	Chem	Phys	Item Recodes
AGREE	282	231	195	1
DISAGREE	174	161	170	3
UNCERTAIN	187	147	123	2
Nonresponse	31	22	11	
Responding	643	539	488	
Mean	1.833	1.871	1.948	
SD	.826	.844	.864	

A16 In my future career, I would like to use the science I learned at school.

	Bio	Chem	Phys	Item Recodes
AGREE	340	386	347	3
DISAGREE	156	65	63	1
UNCERTAIN	149	89	78	2
Nonresponse	29	22	11	
Responding	645	540	488	
Mean	2.286	2.592	2.581	
SD	.830	.696	.710	

A17 Science will help to make the world a better place in the future.

	Bio	Chem	Phys	Item Recodes
AGREE	415	379	350	3
DISAGREE	41	19	31	1
UNCERTAIN	185	142	108	2
Nonresponse	33	22	11	
Responding	641	540	489	
Mean	2.583	2.667	2.652	
SD	.611	.541	.596	

A18 Scientific discoveries do more harm than good.

	Bio	Chem	Phys	Item Recodes
AGREE	50	40	32	1
DISAGREE	427	358	338	3
UNCERTAIN	167	142	117	2
Nonresponse	29	22	11	
Responding	644	540	487	
Mean	2.584	2.528	2.627	
SD	.632	.626	.606	

A19 Science and technology are the cause of many of the world's problems.

	Bio	Chem	Phys	Item Recodes
AGREE	199	155	141	1
DISAGREE	288	259	262	3
UNCERTAIN	153	126	82	2
Nonresponse	34	23	14	
Responding	640	540	485	
Mean	2.138	2.193	2.249	
SD	.862	.855	.878	

A20 I generally dislike my schoolwork.

	Bio	Chem	Phys	Item Recodes
AGREE	218	158	137	1
DISAGREE	339	312	277	3
UNCERTAIN	86	71	74	2
Nonresponse	31	22	11	
Responding	643	541	488	
Mean	2.189	2.285	2.287	
SD	.912	.888	.876	

A21 I would like to become a science teacher when I leave school.

	Bio	Chem	Phys	Item Recodes
AGREE	14	16	14	3
DISAGREE	581	472	431	1
UNCERTAIN	48	52	43	2
Nonresponse	31	22	11	
Responding	643	540	488	
Mean	1.118	1.156	1.146	
SD	.382	.438	.429	

A22 Science is an enjoyable school subject.

	Bio	Chem	Phys	Item Recodes
AGREE	418	408	388	3
DISAGREE	126	74	45	1
UNCERTAIN	100	59	55	2
Nonresponse	30	22	12	
Responding	644	541	488	
Mean	2.453	2.618	2.705	
SD	.801	.714	.626	

A23 The science taught at school is interesting.

	Bio	Chem	Phys	Item Recodes
AGREE	435	387	367	3
DISAGREE	119	77	49	1
UNCERTAIN	89	75	72	2
Nonresponse	30	23	11	
Responding	643	539	488	
Mean	2.492	2.575	2.652	
SD	.787	.729	.655	

A24 Science is a difficult subject.

	Bio	Chem	Phys	Item Recodes
AGREE	335	277	221	1
DISAGREE	241	197	189	3
UNCERTAIN	60	63	73	2
Nonresponse	38	24	16	
Responding	636	537	483	
Mean	1.851	1.851	1.934	
SD	.941	.929	.920	

A25 Science is difficult when it involves calculations.

	Bio	Chem	Phys	Item Recodes
AGREE	362	191	101	1
DISAGREE	191	301	341	3
UNCERTAIN	90	46	45	2
Nonresponse	30	24	12	
Responding	643	538	487	
Mean	1.736	2.205	2.492	
SD	.889	.935	.816	

A26 Science is difficult when it involves handling apparatus.

	Bio	Chem	Phys	Item Recodes
AGREE	120	79	62	1
DISAGREE	447	420	389	3
UNCERTAIN	76	41	38	2
Nonresponse	30	22	11	
Responding	643	540	489	
Mean	2.508	2.632	2.670	
SD	.791	.725	.689	

A27 There are too many facts to learn in science.

	Bio	Chem	Phys	Item Recodes
AGREE	238	170	108	1
DISAGREE	324	299	306	3
UNCERTAIN	82	69	73	2
Nonresponse	30	24	12	
Responding	644	538	487	
Mean	2.133	2.240	2.406	
SD	.926	.903	.829	

A28 Science is relevant to everyday life.

	Bio	Chem	Phys	Item Recodes
AGREE	498	434	395	3
DISAGREE	46	38	33	1
UNCERTAIN	99	65	60	2
Nonresponse	31	24	12	
Responding	643	537	488	
Mean	2.703	2.736	2.742	
SD	.593	.581	.572	

APPENDIX I

FREQUENCY DISTRIBUTION FOR SISS-U.S. ADVANCED SCIENCE TEACHER RESPONSES TO QUESTIONNAIRE ITEMS

TQ01 Age

	Bio	Chem	Phys	Item Recodes
Age 27 or younger	3	2	3	27
Age 28-37 years	7	8	9	33
Age 38-47 years	22	14	12	43
Age 48-57 years	8	8	6	53
Age 58 or older	3	4	3	58
Nonresponse	0	2	1	
Responding	43	36	33	
Mean	43.436	43.595	42.384	
SD	8.328	9.260	9.421	

TQ02 Years of full-time college education completed

	Bio	Chem	Phys	Item Recodes
No further ed	0	0	0	0
Up to 2 yrs	1	1	0	2
Between 2-4 yrs	1	0	0	3
Between 4-6 yrs	20	21	13	5
More than 6 yrs	21	16	21	7
Nonresponse	0	0	0	
Responding	43	38	34	
Mean	5.906	5.785	6.248	
SD	1.192	1.128	.970	

TQ03 Percent of college education spent studying science subjects

	Bio	Chem	Phys	Item Recodes
No further ed	0	0	0	SystemMissing
No study at coll	1	0	0	0
25% or less	1	0	2	25
Between 25-50%	14	16	15	38
More than 50%	27	21	17	51
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	45.118	45.333	43.918	
SD	9.671	6.453	7.768	

TQ04 Years of teaching experience

	Bio	Chem	Phys	Item Recodes
Up to 5 yrs	3	3	4	5
Between 5-10 yrs	6	4	4	8
Between 10-20 yrs	20	19	10	15
Between 20-30 yrs	13	7	12	25
More than 30 yrs	0	5	3	31
Nonresponse	1	0	1	
Responding	42	38	33	
Mean	16.553	17.594	17.811	
SD	6.648	7.663	8.213	

TQ05 Certified to teach class being tested

	Bio	Chem	Phys	Item Recodes
YES	42	37	33	1
NO	1	0	1	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	.969	1.000	.957	
SD	.173	.000	.202	

TQ06 Certification in science fields (numbers indicate total positive responses for the given subject areas by subgroup)

	Bio	Chem	Phys
601-Physics	6	14	33
602-Biology	42	19	6
603-Gen Sci	32	30	22
604-LifSci	23	14	5
605-Sci(N-9)	4	8	7
606-Chem	14	37	15
607-EarthSci	11	11	6
608-PhysSci	14	20	25
609-M/JRHS	11	17	17
610-Elem	43	3	2
611-Other	2	1	4

TQ07 Have teaching responsibilities in science outside area of certification

	Bio	Chem	Phys	Item Recodes
YES	2	1	4	1
NO	41	36	30	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	.047	.023	.111	
SD	.212	.149	.315	

TQ08 Annual gross salary received as a teacher (answer is optional)

	Bio	Chem	Phys	Item Recodes
<$15,000	4	2	0	15
$16,000 - 20,000	10	6	8	18
$21,000 - 25,000	14	14	2	23
$26,000 - 30,000	9	5	9	28
>$30,000	7	10	13	31
Nonresponse	0	1	2	
Responding	44	37	32	
Mean	23.395	24.485	26.511	
SD	5.138	5.127	5.164	

TQ09 Students use calculators during science lessons

	Bio	Chem	Phys	Item Recodes
Frequently	7	34	29	4
Occasionally	14	2	4	3
Rarely	14	1	1	1
Never	9	0	0	0
Nonresponse	0	1	0	
Responding	44	37	34	
Mean	1.919	3.848	3.772	
SD	1.435	.593	.647	

TQ10 Have access to computer at school for use in science teaching

	Bio	Chem	Phys	Item Recodes
YES	29	29	31	1
NO	14	8	3	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	.681	.780	.904	
SD	.467	.415	.294	

TQ11 Frequency of teacher or students using a computer during science lessons

	Bio	Chem	Phys	Item Recodes
Frequently	2	2	3	4
Occasionally	10	5	9	3
Rarely	12	12	18	1
Never	19	19	4	0
Nonresponse	0	0	0	
Responding	43	38	34	
Mean	1.138	.890	1.683	
SD	1.313	1.189	1.235	

TQ12 Member of a science teachers or science association

	Bio	Chem	Phys	Item Recodes
YES	27	20	23	1
NO	16	17	11	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	.619	.544	.686	
SD	.486	.499	.465	

TQ13 Frequency of reading academic journals or other periodicals related to teaching in general

	Bio	Chem	Phys	Item Recodes
Each week	6	6	9	4
Each month	18	17	14	3
Occasionally	14	13	7	2
Rarely or Never	5	2	4	0
Nonresponse	0	0	0	
Responding	43	38	34	
Mean	2.496	2.697	2.668	
SD	1.093	.901	1.236	

TQ14 Frequency of reading journals or periodicals on science subjects

	Bio	Chem	Phys	Item Recodes
Each week	23	13	20	4
Each month	12	14	7	3
Occasionally	8	10	6	2
Rarely or Never	0	0	1	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	3.362	3.077	3.294	
SD	.762	.787	1.011	

TQ15 Total amount of time spent on inservice training related to science or the teachging of science during last 12 months

	Bio	Chem	Phys	Item Recodes
None	9	7	3	0
Less than 1 day	5	1	4	1
1 - 2 days	9	5	8	2
3 - 5 days	4	13	5	4
More than 5 days	16	10	14	6
Nonresponse	0	2	0	
Responding	43	36	34	
Mean	3.133	3.375	3.640	
SD	2.437	2.185	2.195	

TQ16 Percent of teaching of science that takes place in room or laboratory equipped for science teaching and/or student laboratory work

	Bio	Chem	Phys	Item Recodes
None	0	0	0	0
Some; <40%	1	1	1	20
41 - 60%	0	4	1	50
61 - 80%	0	1	0	70
>80%	42	30	31	90
Nonresponse	0	2	1	
Responding	43	36	33	
Mean	88.759	82.918	85.820	
SD	8.532	16.204	15.325	

TQ17 Hours per week (on average) spent outside school hours marking tests and examinations and preparing lessons for all subjects taught, including science

	Bio	Chem	Phys	Item Recodes
Up to 3 hrs	8	2	4	3
Between 3-6 hrs	7	4	5	5
Between 6-10 hrs	11	8	5	8
Between 10-15 hrs	7	15	9	13
More than 15 hrs	10	7	9	16
Nonresponse	0	2	2	
Responding	43	36	32	
Mean	9.382	11.704	10.432	
SD	4.877	4.004	4.796	

TQ18 Number of hours spent at school in a typical week teaching science subjects

	Bio	Chem	Phys	Item Recodes
<5 hours/wk	0	0	0	4
Between 5-10 hrs	3	4	7	8
Between 10-15 hrs	1	1	1	13
Between 15-20 hrs	3	9	6	18
>20 hours/wk	36	23	20	21
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	19.609	18.628	17.624	
SD	3.658	4.087	5.182	

TQ19 Number of hours spent at school in a typical week teaching mathematics subjects

	Bio	Chem	Phys	Item Recodes
<5 hours/wk	42	37	28	4
Between 5-10 hrs	1	0	0	8
Between 10-15 hrs	0	1	4	13
Between 15-20 hrs	0	0	2	18
>20 hours/wk	0	0	0	21
Nonresponse	0	0	0	
Responding	43	38	34	
Mean	4.117	4.152	5.835	
SD	.675	1.161	4.155	

TQ20 Number of hours spent at school in a typical week teaching other subjects

	Bio	Chem	Phys	Item Recodes
<5 hours/wk	42	37	34	4
Between 5-10 hrs	1	1	0	8
Between 10-15 hrs	0	0	0	13
Between 15-20 hrs	0	0	0	18
>20 hours/wk	0	0	0	21
Nonresponse	0	0	0	
Responding	43	38	34	
Mean	4.190	4.058	4.000	
SD	1.096	.478	.000	

TQ21 Number of hours spent at school in a typical week marking tests and examinations and preparing lessons

	Bio	Chem	Phys	Item Recodes
<5 hours/wk	10	7	9	4
Between 5-10 hrs	22	19	19	8
Between 10-15 hrs	7	8	4	13
Between 15-20 hrs	3	3	1	18
>20 hours/wk	0	0	1	21
Nonresponse	1	1	0	
Responding	42	37	34	
Mean	8.666	9.219	8.140	
SD	3.878	4.038	3.937	

TQ22 Importance of what students will need when they leave school in determining what will be taught

	Bio	Chem	Phys	Item Recodes
Very important	36	34	28	5
Some importance	6	2	5	4
Little importance	1	1	0	1
No importance	0	0	0	0
Does not apply	0	0	0	SystemMissing
Nonresponse	0	1	1	
Responding	43	37	33	
Mean	4.791	4.872	4.850	
SD	.618	.552	.357	

TQ23 Importance of the official curriculum or syllabus in determining what will be taught

	Bio	Chem	Phys	Item Recodes
Very important	22	15	9	0
Some importance	16	18	19	1
Little importance	4	0	3	2
No importance	0	3	1	3
Does not apply	0	1	2	SystemMissing
Nonresponse	1	1	0	
Responding	42	37	34	
Mean	.581	.774	.920	
SD	.664	.850	.733	

TQ24 Importance of prescribed textbook(s) in determining what will be taught

	Bio	Chem	Phys	Item Recodes
Very important	14	7	4	0
Some importance	20	24	19	1
Little importance	8	4	3	2
No importance	0	0	3	3
Does not apply	1	2	5	SystemMissing
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	.849	.932	1.222	
SD	.712	.551	.808	

TQ25 Importance of the external examinations that the students will have to take in determining what will be taught

	Bio	Chem	Phys	Item Recodes
Very important	14	7	6	5
Some importance	19	24	20	4
Little importance	6	4	7	1
No importance	3	1	0	0
Does not apply	0	0	1	SystemMissing
Nonresponse	1	2	0	
Responding	42	36	34	
Mean	3.592	3.745	3.484	
SD	1.629	1.268	1.412	

TQ26 Importance of what students will need in next grade or next science course in determining what will be taught

	Bio	Chem	Phys	Item Recodes
Very important	27	33	12	5
Some importance	13	3	16	4
Little importance	3	1	5	1
No importance	0	0	0	0
Does not apply	0	0	0	System Missing
Nonresponse	0	1	1	
Responding	43	37	33	
Mean	4.426	4.813	3.892	
SD	1.021	.693	1.337	

TQ27 Importance of developing the ability of the students to think scientifically in determining what will be taught

	Bio	Chem	Phys	Item Recodes
Very important	35	32	32	5
Some importance	7	4	2	4
Little importance	1	1	0	1
No importance	0	0	0	0
Does not apply	0	0	0	SystemMissing
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	4.763	4.804	4.767	
SD	.638	.633	.939	

TQ28 Importance of helping students to acquire a systematic knowledge of scientific coincepts in determining what will be taught

	Bio	Chem	Phys	Item Recodes
Very important	39	33	29	5
Some importance	4	3	3	4
Little importance	0	1	2	1
No importance	0	0	0	0
Does not apply	0	0	0	SystemMissing
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	4.907	4.835	4.710	
SD	.291	.617	.884	

TQ29 Importance of the availability of laboratory equipment in determining what will be taught

	Bio	Chem	Phys	Item Recodes
Very important	26	22	9	5
Some importance	15	12	17	4
Little importance	1	3	7	1
No importance	0	0	1	0
Does not apply	0	0	0	SystemMissing
Nonresponse	1	1	0	
Responding	42	37	34	
Mean	4.540	4.367	3.560	
SD	.742	1.064	1.523	

TQ30 Frequency of using question-and-answer methods

	Bio	Chem	Phys	Item Recodes
Frequently	33	28	24	4
Occasionally	10	9	10	3
Rarely	0	0	0	1
Never	0	0	0	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	3.761	3.761	3.693	
SD	.427	.427	.462	

TQ31 Frequency of lecturing to the class

	Bio	Chem	Phys	Item Recodes
Frequently	22	24	22	4
Occasionally	16	12	12	3
Rarely	5	0	0	1
Never	0	0	0	0
Nonresponse	0	2	0	
Responding	43	36	34	
Mean	3.276	3.663	3.616	
SD	.955	.473	.572	

TQ32 Frequency of all students doing the same assignment

	Bio	Chem	Phys	Item Recodes
Frequently	34	33	31	4
Occasionally	9	4	1	3
Rarely	0	0	2	1
Never	0	0	0	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	3.784	3.893	3.762	
SD	.412	.310	.783	

TQ33 Frequency of having class divided into small groups of students

	Bio	Chem	Phys	Item Recodes
Frequently	16	11	10	4
Occasionally	18	19	19	3
Rarely	8	4	5	1
Never	1	3	0	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	3.006	3.189	2.985	
SD	1.080	.864	.941	

TQ34 Frequency of students following individual programs in class

	Bio	Chem	Phys	Item Recodes
Frequently	2	0	1	4
Occasionally	13	10	9	3
Rarely	22	18	13	1
Never	6	8	10	0
Nonresponse	0	2	1	
Responding	43	36	33	
Mean	2.155	2.251	2.547	
SD	1.242	1.275	1.309	

TQ35 Frequency of using audio-visual materials in class

	Bio	Chem	Phys	Item Recodes
Frequently	22	5	10	4
Occasionally	19	20	16	3
Rarely	2	13	8	1
Never	0	0	0	0
Nonresponse	0	0	0	
Responding	43	38	34	
Mean	3.417	2.455	2.832	
SD	.734	1.095	1.101	

TQ36 Frequency of having class go on science field trips

	Bio	Chem	Phys	Item Recodes
Frequently	2	0	0	4
Occasionally	9	2	3	3
Rarely	20	22	20	1
Never	12	13	11	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	2.404	2.176	2.148	
SD	1.348	1.432	1.401	

TQ37 Frequency of having guest speakers come in to talk to class

	Bio	Chem	Phys	Item Recodes
Frequently	0	0	0	4
Occasionally	10	3	4	3
Rarely	24	27	22	1
Never	9	6	7	0
Nonresponse	0	2	1	
Responding	43	36	33	
Mean	2.080	1.707	1.904	
SD	1.261	1.199	1.278	

TQ38 Frequency of presenting science demonstrations to class

	Bio	Chem	Phys	Item Recodes
Frequently	12	15	21	4
Occasionally	25	17	12	3
Rarely	6	5	1	1
Never	0	1	0	0
Nonresponse	0	0	0	
Responding	43	38	34	
Mean	3.002	3.129	3.576	
SD	.918	.969	.594	

TQ39 Frequency of students performing laboratory experiments

	Bio	Chem	Phys	Item Recodes
Frequently	27	32	18	4
Occasionally	16	4	15	3
Rarely	0	1	1	1
Never	0	0	0	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	3.630	3.834	3.428	
SD	.483	.485	.730	

TQ40 Frequency of using standardized tests produced outside the school in assessing work of science students

	Bio	Chem	Phys	Item Recodes
Frequently	4	1	1	4
Ocasionally	7	11	8	3
Rarely	19	17	17	1
Never	13	4	6	0
Nonresponse	0	5	2	
Responding	43	33	32	
Mean	2.540	2.322	2.278	
SD	1.383	1.280	1.310	

TQ41 Frequency of using teacher-made essay tests in assessing work of science students

	Bio	Chem	Phys	Item Recodes
Frequently	16	9	9	4
Occasionally	22	14	14	3
Rarely	3	13	9	1
Never	2	1	2	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	3.256	2.543	2.771	
SD	.804	1.227	1.163	

TQ42 Frequency of using teacher-made objective tests in assessing work of science students

	Bio	Chem	Phys	Item Recodes
Frequently	31	22	20	4
Occasionally	9	14	8	3
Rarely	2	0	3	1
Never	0	1	3	0
Nonresponse	1	1	0	
Responding	42	37	34	
Mean	3.633	3.556	3.476	
SD	.728	.626	.905	

TQ43 Frequency of using performance on homework assignments in assessing work of science students

	Bio	Chem	Phys	Item Recodes
Frequently	20	21	22	4
Occasionally	9	12	6	3
Rarely	13	3	6	1
Never	1	1	0	0
Nonresponse	0	1	0	
Responding	43	37	34	
Mean	2.893	3.413	3.330	
SD	1.294	.875	1.094	

TQ44 Frequency of using performance on laboratory exercises and/or projects in assessing work of science students

	Bio	Chem	Phys	Item Recodes
Frequently	25	34	23	4
Occasionally	16	3	8	3
Rarely	1	0	3	1
Never	0	0	0	0
Nonresponse	1	1	0	
Responding	42	37	34	
Mean	3.542	3.916	3.532	
SD	.650	.278	.841	

APPENDIX J

FREQUENCY DISTRIBUTION FOR SISS-U.S. ADVANCED SCIENCE SCHOOL QUESTIONNAIRE

AQ01 Area served by school

	Bio	Chem	Phys	Item Recodes
Inner.urban.metro	3	5	5	1
Outer.urban.metro	12	5	16	1
urban/suburb.no.metr	13	13	11	0
Rural	11	13	1	0
Nonresponse	1	1	1	
Responding	39	36	33	
Mean	.377	.298	.635	
SD	.485	.458	.482	

AQ02 Approximate population of area served by school

	Bio	Chem	Phys	Item Recodes
>1,000,000	2	1	4	1000
100,000 - 1,000,000	5	5	6	550
10,000 - 100,000	19	24	21	55
1,000 - 10,000	12	7	1	5
<1,000	2	0	0	1
Nonresponse	0	0	2	
Responding	40	37	32	
Mean	152.357	134.864	271.663	
SD	262.295	216.786	341.750	

AQ03 School week divided into periods

	Bio	Chem	Phys	Item Recodes
YES	40	34	33	1
NO	0	2	1	0
Nonresponse	0	1	0	
Responding	40	36	34	
Mean	1.000	1.053	1.043	
SD	.000	.224	.203	

AQ04 Number of periods in a school week

	Bio	Chem	Phys	Item Recodes
<_20	0	0	1	20
21-30	15	14	4	25
31-40	20	20	22	35
41-50	2	2	4	45
>50	0	0	1	51
Nonresponse	3	1	2	
Responding	37	36	32	
Mean	31.586	31.574	34.388	
SD	5.879	5.673	5.818	

A005 Number of minutes in each period

	Bio	Chem	Phys	Item Recodes
<_20	1	0	0	20
21-30	0	0	0	25
31-40	1	0	4	35
41-50	15	14	20	45
>50	20	21	8	55
Nonresponse	3	2	2	
Responding	37	35	32	
Mean	49.223	50.974	46.362	
SD	7.807	4.909	5.904	

A006 Number of hours in a school week

	Bio	Chem	Phys	Item Recodes
<_20	0	0	0	20
21-25	2	1	2	23
26-30	14	10	13	28
31-35	20	20	12	33
>35	3	5	7	37
Nonresponse	1	1	0	
Responding	39	36	34	
Mean	31.118	31.926	31.384	
SD	3.284	3.183	3.894	

A007 Number of days per school year

	Bio	Chem	Phys	Item Recodes
170 days or less	0	0	1	170
171 - 180 days	31	23	24	175
181 - 190 days	9	14	6	185
191 - 200 days	1	0	1	195
more than 200 days	0	0	0	201
Nonresponse	0	0	2	
Responding	40	37	32	
Mean	117.509	178.889	177.452	
SD	4.642	4.880	5.441	

A008 Minimum number of years of high school science (grades 9-12) required of students for graduation from school

	Bio	Chem	Phys	Item Recodes
None or <1yr	0	0	0	0
1 year	5	2	2	1
2 years	27	28	16	2
3 years	7	6	11	3
4 years	0	1	3	4
Nonresponse	1	0	2	
Responding	39	37	32	
Mean	2.051	2.145	2.460	
SD	.546	.531	.751	

A009 Minimum number of years of high school math (grades 9-12) required of students for graduation from school

	Bio	Chem	Phys	Item Recodes
None or <1yr	0	0	0	0
1 year	0	0	1	1
2 years	24	25	9	2
3 years	15	10	21	3
4 years	0	2	0	4
Nonresponse	1	0	3	
Responding	39	37	31	
Mean	2.391	2.383	2.613	
SD	.488	.583	.570	

A010 Number of rooms or laboratories in school equipped for science teaching and/or student laboratory work

	Bio	Chem	Phys	Item Recodes
None	1	0	0	0
1	5	5	2	1
2-4	14	16	2	3
5-9	16	8	19	7
10 rooms or more	4	7	10	10
Nonresponse	0	1	1	
Responding	40	36	33	
Mean	5.193	4.954	7.397	
SD	2.847	3.135	2.341	

A011 Estimate of overall percentage of school week for which these science rooms are used for science lessons/laboratory work

	Bio	Chem	Phys	Item Recodes
<40% of week	0	4	0	39
41-60% of week	6	3	4	50
61-80% week	2	2	8	70
>80% of week	31	27	21	81
No sci rooms at schl	1	0	0	0
Nonresponse	0	1	1	
Responding	40	36	33	
Mean	74.109	73.318	74.644	
SD	15.486	14.786	10.152	

A012 Number of science laboratory assistants/technicians (full-time equivalent)

	Bio	Chem	Phys	Item Recodes
None	34	34	25	0
1	3	1	6	1
2	1	0	0	2
3	0	0	0	3
4 or more	2	0	3	4
Nonresponse	0	2	0	
Responding	40	35	34	
Mean	.311	.022	.506	
SD	.914	.146	1.122	

AQ13 Source of operating costs for the school

	Bio	Chem	Phys	Item Recodes
Total/almost wholly by local and state taxes	35	27	27	2
Partially by local and state taxes	0	5	2	1
Total/almost wholly private sources	5	5	0	0
Nonresponse	0	0	5	
Responding	40	37	29	
Mean	1.767	1.584	1.698	
SD	.642	.728	.682	

AQ14 Existence of committee, organization, or association on which both parents and teachers are formally represented

	Bio	Chem	Phys	Item Recodes
YES	32	24	24	1
NO	7	11	9	0
Nonresponse	1	2	1	
Responding	39	35	33	
Mean	.832	.688	.717	
SD	.375	.464	.451	

AQ15 Organization of science-related activities arranged or carried out by groups involving both paarents and/or teachers

	Bio	Chem	Phys	Item Recodes
YES	16	19	18	1
NO	24	16	15	0
Nonresponse	0	2	1	
Responding	40	35	33	
Mean	.396	.549	.544	
SD	.490	.498	.499	

APPENDIX K

PEARSON CORRELATION COEFFICIENTS FOR SISS-U.S. ADVANCED SCIENCE STUDENT, TEACHER, AND SCHOOL VARIABLES

SISSBIO = 25 international items
SISSCHM = 25 international items
SISSPHYS = 26 international items

* = P < 0.05 ** = P < 0.001

	SISSBIO	SISSCHM	SISSPHYS
SCITOT	** .9752	** .9839	** .9821
MATOT	** .5725	** .5840	** .3989
WKTOT	** .4811	** .3859	** .3803

	Achievement Test Score		
Variable	SISSBIO	SISSCHM	SISSPHYS
Student Questionnaire			
Q02 POSTED	**.2502	**.1585	.0287
Q03 POSTSCI	**.1927	* .1151	*.1318
Q04 HRS/TV/WK	**-.2199	*-.1409	**.1232
Q05 HMWKALL	** .1919	** .1877	.0683
Q06 HMWKSCI	** .1396	** .1715	* .1119
Q07 DESCR/GRADES	** .3739	** .2307	** .1645
Q08 CALOWN	** .2202	** .1808	.0041
Q09 CPTRSCH	* .0705	* .0895	.
Q10 CPTRUSE	.0086	.0232	** .1728
Q11 YRS MATH	** .3082	.0593	* .1158
Q12 FED	** .2346	* .0862	** .2436
Q13 FOCC	** .2250	.0283	** .2571
Q14 MED	** .1961	* .0769	* .1379
Q15 MOCC	** .1776	.0292	* .1013
Q16 HMBOOK	** .2126	* .1037	** .2054
Student Opinionnaire			
A01 SCIUSEFUL	** .2036	* .0732	.0556
A02 SCHCHALLENGIN	**-.1390	.0532	*-.0816
A03 SCIRUINENVIRN	-.0372	*-.1120	.0179
A04 WKLABINTRSTNG	* .0841	-.0064	.0524
A05 SCIMPRSNTRDEV	* .1097	* .0843	.0332
A06 SCHNOTENJOYBL	* .0803	*-.0747	.0359
A07 $SCIWORTHIT	** .1641	.0303	* .0848
A08 FUTJBSRQSCIKW	* .0879	.0517	**-.1926
A09 ANXMODSOCDUSC	* .0796	.0398	* .0975
A10 PEOPSCIBTTROF	** .1404	.0496	* .1285
A11 IMPRTKNWSCIJB	* .1161	.0240	-.0243
A12 BOREDINSCHL	-.0469	**-.1452	-.0687

(table continues)

	Achievement Test Score		
Variable	SISSBIO	SISSCHM	SISSPHYS
A13 SCIINVIMPRSTD	* .1229	.0327	.0054
A14 MNYSUBJNOTLIK	** .1567	-.0332	* .1081
A15 SCINVNTENSION	.0608	* .0994	.0538
A16 FUTRLIKUSESCI	** .2466	.0650	* .0813
A17 SCIWRLDBETTER	* .0841	.0609	.0633
A18 SCIDISCVDOHAR	.0588	* .0947	-.0175
A19 ScTechPRBLMS	* .0829	.0625	* .0860
A20 DISLIKESCHWK	.0232	-.0414	.0091
A21 LIKEBESCITCHR	.0265	.0123	.0641
A22 SCIENJOYBLSUB	** .2740	.0295	** .1508
A23 SCHSCIINTRSTG	** .2035	.0536	* .1057
A24 SCIDIFFICSUBJ	** .1817	.0479	* .1340
A25 SCIDIFFW/CALC	** .2779	** .2212	* .1395
A26 SCIDIFFAPPRAT	** .2031	* .0861	* .0755
A27 TOOmanyFACTS	** .2904	* .1087	** .2198
A28 SCIRELVEVRDAY	** .1419	.0323	* .0975
Description of Science Learning			
D01 USETEXT	-.0537	.0150	-.0075
D02 SCIHMWKONTIME	.0604	-.0616	.0041
D03 TCHR REMINDS	-.0477	-.0043	-.0694
D04 TCHR PREVIEWS	* -.0710	-.0322	* -.1144
D05 TCHR SUMMARIZ	* -.1049	.0442	-.0101
D06 SCIHMWKRTAWAY	* .1223	.0384	.0397
D07 TCHUSESTDIDEA	.0453	-.0010	* .0859
D08 TCHRDEMOS	-.0291	* .0817	-.0193
D09 TCHMKSSCIINTR	* .0896	.0292	.0596
D10 SCIHMKDISTRAC	-.0442	* -.0757	.0148
D11 SCIHMKREPRTLB	** .1596	** .1447	* .0070
D12 TEXPLSCIRELEV	.0244	* .1375	-.0300
D13 TDISCSCICAREE	.0059	-.0666	* -.1170
D14 TESTONSCILRND	.0549	* .0903	.0416
D15 THELPSTD/DIFF	.0199	-.0069	.0221
D16 TRYALLSCIHMWK	.0447	-.0241	.0176
D17 FLDWKOUTOFCLS	-.0153	* -.0711	-.0062
D18 LABWKSCILESSO	-.0007	.0335	-.0323
D19 SMGRPSINSCI	.0309	* .1203	-.0328
D20 TCHINSTRCEXPT	-.0377	* -.0807	-.0005
D21 EXPTLABBOOK	.0112	* .1055	-.0311
D22 OWNPRBLMTHELP	* -.0956	* -.0993	* .0783
D23 TPRBLMOWNHELP	-.0573	-.0218	- .0193
D24 OWNPRBLMOWNHL	-.0419	* -.1314	.0672

(table continues)

	Achievement Test Score		
Variable	SISSBIO	SISSCHM	SISSPHYS
Teacher Questionnaire			
TQ01 - AGE	.0289	** .2982	* .0958
TQ02-POSTED	-.0211	** .2414	-.0133
TQ03-POSTSCI	-.0520	* -.1207	** .1713
TQ04-TEXP	.0201	** .3392	* .1149
TQ05-CERTIFIED	-.0318	.	.0308
TQ 601-PHYSICS	.	**-.3588	-.0308
TQ 602-BIOLOGY	.	** .2511	.0212
TQ 603-GENSCI	.	** .2799	* -.1433
TQ 604-LIFSCI	.	** .1541	.0882
TQ 605-SCI(N-9)	.	-.0347	** .1901
TQ 606-CHEM	.	.	-.0271
TQ 607-EARSCI	.	.0114	** .1676
TQ 608-PHYSSCI	.	.0408	.0155
TQ 609-M/JRHS	.	* .0813	* -.1161
TQ 610-ELEM	.	.0457	-.0395
TQ 611-OTHER	.	* -.0784	** .1662
TQ607-TCHGOUT	-.0498	**-.1805	-.0643
TQ08-GROSALYR	** .1688	** .3455	** .2378
TQ09-TCALCUSE	.0414	-.0168	** -.1895
TQ10-TCPTRSCH	** .1496	** .2766	** .2442
TQ11-TCPTRUSE	** .1752	-.0442	-.0271
TQ12-SCITCHASSN	* .0855	* -.0913	** .2182
TQ13-READGEN	* -.0797	-.0290	.0158
TQ14-READSCI	-.0272	.0198	.0129
TQ15-INSERV	-.0014	.0080	.0096
TQ16-TCHLABRM	-.0295	** .2270	** -.2673
TQ17-MARKOUT	.0530	** .2273	.0743
TQ18-HRSTCHSCI	-.0287	.0289	* .0911
TQ19-HRSTCHMATH	* -.1169	.0287	** -.2442
TQ20-HRSTCHOTHR	-.0124	* .1167	.
TQ21-HRSMARK	.0587	* .0856	** .1778
TQ22-NEEDLEAVE	* .0917	* -.1353	* -.1282
TQ23-SYLLABUS	**-.0814	* .1367	* .0776
TQ24-USE TEXT	**-.1494	**-.2951	* -.3112
TQ25-EXTERNEXAM	* .0664	* .1464	** .1783
TQ26-NEEDNEXTCRSE	.0521	-.0512	* .1296
TQ27-THINKSCITIF	- .0067	* .1091	** -.3261
TQ28-HAVESCIKNOWL	**-.1500	.0705	** -.3346
TQ29 LAB EQUI	* -.1099	-.0747	-.0086
TQ30-USE Q&A	** .1301	** .1764	-.0438
TQ31-LECTURE	* .0996	-.0051	.0729
TQ32-SAMEASSIGNMT	.0624	.0160	-.0736
TQ33-SMGROUPS	*-.1064	* -.1464	* -.1308
TQ34-INDIVASSIGNM	-.0002	**-.2541	** .2544
TQ35-USE A-V	**-.1783	-.0076	* -.0916
TQ36-DO FIELDWRK	*-.1139	-.0223	* -.1146

(table continues)

	Achievement Test Score		
Variable	SISSBIO	SISSCHM	SISSPHYS
TQ37 GUEST SPKR	** .1687	* -.1121	-.0193
TQ38 DO DEMOS	-.0535	-.0505	** .2500
TQ39 STDNT EXPTS	** .1451	* .1345	** -.2209
TQ40-UseStdrdTest	.0628	* .1069	** .1813
TQ41-TchrEssayTst	** .2305	* .0880	-.0182
TQ42-TchrObj.Test	.0041	-.0397	**-.2117
TQ43-EvalHMWK	.0063	.0731	-.0229
TQ44-EvalProject	.0463	* .1375	* -.1079
School Administrator Questionnaire			
AQ01 LOCATION	* .0909	** .2625	** .2418
AQ02 AREAPOPN	* .0988	.0626	** .2926
AQ03 SCHPERIODS	.	** .4716	** -.1799
AQ04 NPERIODS	.0510	.0493	** .2273
AQ05 NRMINUTES	*-.0956	** -.2388	** -.3142
AQ06 NRHOURS	* .1070	.0304	-.0588
AQ07 WEEKS/YR	* .0938	** .2821	-.0638
AQ08 MINYRSSCIENC	.0137	* -.1078	-.0446
AQ09 MINYRSMATH	** .2170	**-.1504	* -.1451
AQ10 # OF LABRMS	** .2595	** .2516	** .2885
AQ11 % LABUSE	* .0719	** .2342	* .0875
AQ12 # LABASSTS	* -.0743	* .1077	.0766
AQ13 OPCOST SOURC	.0078	** .1626	.0214
AQ14 PRNTTCHRCOMM	** .1528	.0526	.0304
AQ15 SCIACTIVCOMM	* .0707	* -.0846	* -.1427

APPENDIX L

PARTIAL CORRELATION COEFFICIENTS FOR SELECTED SISS-U.S. ADVANCED SCIENCE STUDENT, TEACHER, AND SCHOOL VARIABLES

Student Variables and Composite Variables With SISS Science Achievement on International Common Items

Controlling for Home, Teacher, and School Variables (including class size and expenditure for science materials, texts, equipment, and supplies):

	Achievement Test		
Variable/Composite	SISSBIO	SISSCHM	SISSPHYS
MATOT (Mathematics Test)	** .5242	** .3971	** .2947
WKTOT (Word Knowledge)	** .4177	** .2169	** .2529
Ability (MATOT + WKTOT)	** .4466	** .4225	** .2931
Years of math studied	** .2302	.0712	* .1121
Aspirations	** .2109	.0521	.0920
Years of science studied	** .2879	.0998	* .1321
Years of PhysSci studied	** .2847	* .1114	** .2223
Years of BiolSci studied	.0380	- .0384	.0129
Science Interest	** .2645	* .1089	* .1438
Science Attitudes	** .2765	** .1833	* .1109

** p < .001
* p < .05

Teacher Variables and Composite Variables With SISS Science Achievement on International Common Items

Controlling for Student, Home, and School Variables (including class size, and expenditure for science materials, texts, equipment, and supplies):

	Achievement Test		
Variable/Composite	SISSBIO	SISSCHM	SISSPHYS
Sex	- .0802	* - .1645	* - .1821
Posteducation	.0141	* .1410	- .0413
Posteduc. in science	- .0387	- .0152	- .0413
Teaching experience	.0540	* .1887	.1070
Member in sci. assn.	- .0957	* .1466	- .0928
Read gen'l ed. jrnls	- .0696	- .0263	.0003
Read sci. jrnls	- .0249	- .0008	- .0878
Inservice	- .0588	.0790	- .0196
Little import. of syllabus	- .0038	.0672	- .0558
Little import. of text	* .1000	** .3183	.0335
Import. of external exam	.0406	.0342	* .1819
Use standardized tests	- .0024	.0040	.0226
Use tchr-made essay tests	* .0973	* .1788	- .0317
Use tchr-made obj. tests	- .0147	- .0027	** - .2295
Use hawk to assess student	* .1201	- .0505	- .1008
Use labwk to assess student	.0767	** .2087	.0331
Use question/answer	.0941	.0039	.1030
Use lecture	.0941	- .0991	.0215
Use audio-visual	- .0299	- .0803	.0250
Do demos	.0296	.0706	.0521
Students do expts.	- .0628	.0539	.0154

** p < .001
 * p < .05

School Variables and Composite Variables With SISS Science Achievement on International Common Items

Controlling for Student, Home, and Teacher Variables:

Variable/Composite	Achievement Test		
	SISSBIO	SISSCHM	SISSPHYS
Number of periods/week	* .0903	- .0572	.0378
Number of minutes/period	- .0166	- .0841	*- .1328
Number of weeks/year	.0595	.0172	- .0235
Percent lab use	* .1193	.0956	.0410
Number male sci. tchrs	.0626	* .1350	.0512
Number female sci. tchrs	* .0792	- .0229	.0375
Money spent on equipment	- .0098	*- .1367	- .0034
Money spent on supplies	*- .0922	- .0293	.0226
Money spent on texts	- .0007	- .0549	.0273
Money spent on other (inc. field trips)	- .0333	- .0407	.0044
Class size	*- .1038	* .1392	.0673